OS-001

Historical Arctic sea ice variations: uncertainties and reconstructions

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The shrinking Arctic sea ice area (SIA) in recent decades is a striking manifestation of the ongoing climate change. Variations of the Arctic sea ice have been continuously observed by satellites since 1979 [Matveeva and Semenov, 2022], relatively well monitored since the 1950s, but are highly uncertain in the earlier period due to a lack of observations. The middle of the 20th century was characterized by a strong warming in the Arctic, so called the Early Twentieth's Century Warming (ETCW), which magnitude has been just recently exceeded by the ongoing warming [Bokuchava and Semenov, 2021]. Whereas temperature variations during ETCW are relatively well established, there is no agreement on whether the warming has been accompanied by a rapid sea ice retreat as in the modern period.

Several reconstructions of the historical gridded sea ice concentration (SIC) data were recently presented based on synthesized regional sea ice observations or by applying a hybrid model-empirical approach. We present a new SIC reconstruction for 1901-2019 period based on established co-variability between SIC and surface air temperature, sea surface temperature, and sea level pressure patterns [Semenov et al., 2024]. The reconstructed sea ice data for March and September are compared to frequently used HadISST1.1 and SIBT1850 datasets. The new reconstruction shows a large decrease in SIA from the 1920 to 1940 concurrent with the Early 20th Century Warming event in the Arctic. Such a negative SIA anomaly is absent in HadISST1.1 data. The amplitude of the SIA anomaly reaches about 0.8 mln.km2 in March and 1.5 mln.km2 in September. The anomaly is about three times stronger than that in the SIBT1850 dataset. The larger decrease in SIA in September is largely due to the stronger SIC reduction in the western Sector of the Arctic Ocean in the 70°-80°N latitudinal zone.

The new reconstruction provides gridded monthly data that can be used as boundary conditions for atmospheric reanalyses and model experiments to study the Arctic climate for the first half of the 20th century. Such experiments were earlier conducted using the conventional HadISST1 data, and showed that ETCW in the

Arctic cannot be reproduced without having a negative sea ice anomaly in that period [Semenov and Latif, 2012].

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OS-002

The Observed Near-surface Energy Exchange Processes over Arctic Glacier in summer

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Under Arctic warming, near-surface energy transfers have significantly changed, but few studies have focused on energy exchange over Arctic glaciers due to limitations in available observations. In this study, the atmospheric energy exchange processes over the Arctic glacier surface were analyzed by using observational data obtained in summer 2019 in comparison with those over the Arctic tundra surface. The energy budget over the glacier greatly differed from that over the tundra, characterized by less net shortwave radiation and downward sensible heat flux, due to the high albedo and icy surface. Most of the incoming solar radiation was injected into the glacier in summer, leading to snow ice melting. During the observation period, strong daily variations in near-surface heat transfer occurred over the Arctic glacier, with the maximum downward and upward heat fluxes occurring on 2 and 6 July 2019, respectively. Further analyses suggested that the maximum downward heat flux is mainly caused by the strong local thermal contrast above the glacier surface, while the maximum upward heat transfer cannot be explained by the classical turbulent heat transfer theory, possibly caused by countergradient heat transfer. Our results indicated that the near-surface energy exchange processes over Arctic glaciers may be strongly related to local forcings, but a more in-depth investigation will be needed in the future when more observational data become available.

Key Words: Arctic, glacier, tundra, energy exchange processes

OS-003

The role of Arctic sea ice loss in the interdecadal trends of the East Asian summer monsoon in a warming climate

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The East Asian summer monsoon precipitation has exhibited a well-known "southern China flood and northern China drought" pattern in recent decades. The increase in aerosols and warming oceans are recognized as two important forcings that control of the precipitation trends over East Asian land. However, in this study, by using large ensemble simulations from the CMIP6 Polar Amplification Model Intercomparison Project (PAMIP), the influence of Arctic amplification, serving as the prominent feature of global warming, is very important in modulating the East Asian summer precipitation pattern, which is comparable to the influence of sea surface temperature (SST). Additionally, the observed "southern China flood and northern China drought" pattern only exists in July and August, whereas a triple pattern with the precipitation positive anomaly center over Middle China occurs in June. These patterns are closely connected with the regional differences in Arctic sea ice loss from June to July, affected through both the Rossby waves propagating in a weaker westerly jet and the decrease in the large-scale meridional thermal contrast in a warming climate.

OS-004

Baroclinic instability in geophysical hydrodynamics problems

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Baroclinic instability is that of flows in a rotating stratified fluid with a vertical velocity shear. The generation of large-scale vortical flows in the atmospheres of Earth and other planets is associated with this instability [1]. This report presents some of recent theoretical results in this field obtained in A.M. Obukhov Institute of Atmospheric Physics.

The mechanism of generation of gravity waves by potential vorticity (PV) disturbances in flows with constant horizontal and vertical shears is studied [2]. The case of the initial singular distribution of PV, in which the PV is localized in one coordinate and is periodic with respect to other coordinates, is considered. In a stratified medium, such a distribution induces a vortex wave, the propagation of which is accompanied by the emission of gravity waves. The asymptotic solutions of the equations are constructed for small Rossby numbers (horizontal shear) and large Richardson numbers (vertical shear).

Within the framework of the Eady model, an analytical approach to the determination of optimal perturbations with a maximum of the energy growth rate or, alternatively, the ratio of the final and initial energies is considered [3]. This approach is based on the energy balance equation and explicit expressions for the energy functionals resulting from the perturbation representation as the superposition of the edge Rossby waves (ERWs) [4]. The optimal regime of ERWs excitation by the initial singular distribution of PV is investigated. The horizontal shear makes the mechanism of generation of baroclinic waves by initial vortex perturbations more efficient [5].

The maximally truncated surface quasigeostrophic (SQG) model was used to describe the dynamics of disturbances of a flow with a constant vertical shear in a zonal channel [6]. A dynamic system describing nonlinear interactions between unstable counter-propagating Rossby waves with one zonal wave number and a neutral mode independent of zonal coordinate has been formulated. Both analytical and numerical solutions of the system show that exponentially increasing disturbances at the linear stage of instability development give way to nonlinear oscillations (vacillations).

The SQG model is developed to describe the dynamics of flows with zero potential vorticity in the presence of one or two horizontal boundaries [7]. The Galerkin method is also used to study the nonlinear dynamics of perturbations. The results of numerical integration of full nonlinear SQG equations confirm this analysis.

Using the two-level version of the SQG model, which is similar to the classical two–layer Phillips model, the linear stability of jet flows induced by piecewise constant boundary distributions of buoyancy is investigated [8]. It is shown that the most unstable perturbation has a wavelength of the order of the Rossby baroclinic radius of deformation.

The stability of a flow with a constant vertical shear is investigated in the frame of a two-level quasi-geostrophic model. In the model with bottom friction and for a wide range of parameter values, the system solutions exhibit complex chaotic behavior. Thus, chaos or turbulence emerges for large-scale motions [9].

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OS-005

Potentials of the Fengyun Satellites in Solar Energy

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The Fengyun satellites, managed by the China Meteorological Administration, represent a significant advancement in meteorological satellite technology. Its advanced features hold substantial promise for enhancing aerosol, cloud, and radiation retrievals, which are crucial for solar energy assessment and forecasting. In this presentation, we will present preliminary results on aerosol, cloud, and radiation retrievals using FY-4A AGRI measurements, and explore their applications in the solar energy industry.

OS-006

Structure and dynamics of the atmospheric boundary layer in conditions of heterogeneous peatland topography

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The study presents the results from the multi-platform observational campaign carried out at the West-Siberian peatland [1] and polygonal Siberian tundra. The focus of the study is the quantification of spatial contrasts of the surface heat budget terms and methane emissions across the peatland, which arise due to the presence of microlandscape heterogeneities. It is found that surface temperature contrasts across the peatland exceeded 10 °C for clear-sky conditions both during day and night. Diurnal variation of surface temperature was strongest over ridges and drier hollows and was smallest over the waterlogged hollows and shallow lakes. This resulted in strong spatial variations of sensible heat flux and Bowen ratio, while the latent heat varied much less. During the clear-sky days, H over ryam exceeded the one over the waterlogged hollow by more than a factor of two. The Bowen ratio amounted to about unity over ryam, which is similar to values over forests. Methane emissions estimated using the static-chamber method also strongly varied between various microlandscapes, being largest at a hollow within a ridge-hollow complex and smallest at a ridge. A strong nocturnal increase in methane mixing ratio was observed and was used in the framework of the atmospheric boundary layer budget method to estimate nocturnal methane emissions, which were found to be in the same order of magnitude as daytime emissions. Finally, the directions for further research are outlined, including the verification of flux-aggregation techniques, parameterizations of surface roughness and turbulent exchange, and land-surface model evaluation and development. The complex thermal structure of the polygonal tundra allows us to develop parameterizations of the influence of thermally heterogeneous relief on the characteristics of energy exchange in the surface layer.

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and methane emissions over West-Siberian peatland: Highlights from the Mukhrino 2022 Campaign. Forests **15**(1): 102, 2024.

OS-007

The Characteristic of Multi-scale Flow Structure and its Parameterization on Air-Sea Flux in the Atmospheric Boundary Layer

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Multi-scale structures are an apparent phenomenon in atmospheric turbulence. The characteristic forms of these fluctuations (with spatial scales ranging from ten to several hundred meters) have both distinct geometric and dynamic properties. From the land atmospheric boundary layer to the marine atmospheric boundary layer, we have found that the effect of coherent structures on flux transport is very significant, even more so than turbulence.

We discovered coherent structures during strong wind periods in East Asia, particularly during large-scale dust storms after the passage of a cold front in spring, and found that air motion during dust storms can be divided into three components: turbulent small eddies, gusty wind, and basic flow. And then we analyzed the structures and characteristics of the windy atmospheric boundary layer observed in the South China Sea region during the cold surges and typhoon periods. The coherent gusty disturbances provide a mechanical mechanism for lifting up dust and spume droplets. Lastly, we studied the multi-scale characteristics of flow structures in coastal regions. The flow structure in the atmospheric boundary layer in coastal areas is significantly impacted by the underlying surface. Different scales make varying contributions to momentum flux.

Keywords: coherent structure, atmospheric boundary layer, air-sea flux, complex terrain

OS-008

Hysteresis of the global carbon cycle to anthropogenic CO_2 emissions into the atmosphere

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Idealized numerical experiments have been performed with the earth system model developed at the A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences (IAP RAS ESM), under anthropogenic CO_2 emissions into the atmosphere, which increase initially and decrease afterwards. These numerical experiments revealed the inertia of various components of the earth system, leading to a delay in the response of various components of the carbon cycle relative to the anthropogenic emissions by several decades. The inertia of the carbon cycle components leads to a hysteresis response of its characteristics to anthropogenic CO_2 emissions into the atmosphere that are nonmonotonic in time and, noticeable, in particular, for the gross primary production and respiration of plants and soil. In turn, the hysteresis response of the characteristics of the global carbon cycle indicates the irreversibility of its changes on the scale of (at least) several decades. The latter should be taken into account when planning for adapting and/or mitigating climate change.

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OS-009

Time series prediction combined with slow feature analysis

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Almost all climate time series have some degree of nonstationarity due to external driving forces perturbing the observed system. Therefore, these external driving forces should be taken into account when constructing the climate dynamics. This paper presents a new technique of obtaining the driving forces of a time series from the Slow Feature Analysis (SFA) approach, then introducing them into a predictive model to predict non-stationary time series. The basic theory of the technique is to consider the driving forces as state variables and incorporate them into the predictive model. Experiments using a modified logistic time series and winter ozone data in Arosa, Switzerland, were conducted to test the model. The results showed improved prediction skills. In addition, the results show that the signal of volcanic eruptions can be found in the driving force, and wavelet analysis of this driving force shows that there are two main dominant scales, which may be connected with the effect of climate mode such as North Atlantic Oscillation (NAO) and solar activity. This study represents a contribution to understanding of the causality from observed climate data.

OS-010

Marine Weather Observer（MWO）：a mobile long-endurance ocean weather observation system

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A mobile long-endurance ocean weather observation system, named Marine Weather Observer（MWO）, has been developed based on a totally solar powered unmanned surface vehicle. This system is featured by the autonomous navigation, the long- endurance of 100 days, the full operation with solar power, and the capability to measure the air pressure, temperature, humidity, wind speed, wind direction and the total solar radiation over ocean and the sea surface temperature as well as the salinity. It has been tested and used during several field experiments over last 7 years. Some observation results are presented in this report.

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OS-011

Vertical helicity flux as an index of the intensity of atmospheric motions

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Non-zero helicity values (defined by a dot product of velocity and vorticity vectors) are immanent to many atmospheric motions ranging from micro- to large-scale ones. While the helicity of micro- and mesoscale motions occurring in the free atmosphere is typically buoyantly (convectively) driven, the helicity of large-scale motions is baroclinic in origin. For the entire range of helical motions, the primary sink of helicity is confined to the atmospheric boundary layer. Therefore, the vertical helicity flux across the top of the boundary layer, directed from the helicity source to its sink, can be regarded as a useful index of the helicity content of atmospheric motions and ultimately of their intensity and destructive potential. This methodology is applied to quantify the intensity and destructive potential of tornadoes and tropical cyclones [1]. Comparison with commonly used metrics, e.g., integrated kinetic energy (IKE) [2], shows a good correlation [3]. The vertical helicity flux correlates well with metrics, such as the area swept by hurricane-force winds in violent tornadoes [4]. Working formulas for the vertical helicity flux in large-scale atmospheric motions [5] are used to calculate a hemisphere-averaged vertical helicity flux (latitudes greater than 20 degrees), which appears to be a good index of atmospheric general circulation variability on seasonal and interannual time scales [6]. The concept of vertical helicity flux also works well in diagnosing two destructive derecho events over European Russia in the summer of 2010 [7]. The main ideas and findings of this work are summarized in [8].

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OS-012

Can soil effectively sequester carbon for climate change mitigation?

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Plant root-derived carbon (C) inputs (Iroot) are the primary source of C in mineral bulk soil. However, a fraction of Iroot may lose quickly (Iloss, e.g., via rhizosphere microbial respiration, leaching and fauna feeding) without contributing to long-term bulk soil C storage, yet this loss has never been quantified, particularly at global scale. In this study we integrated three observational global data sets including soil radiocarbon content, allocation of photosynthetically assimilated C, and root biomass distribution in 2,034 soil profiles to quantify Iroot and its contribution to the bulk soil C pool. We show that global average Iroot in the 0-200 cm soil profile is 3.5 Mg ha-1 yr-1, ~80% of which (i.e., Iloss) is lost rather than contributing to long-term bulk soil C storage. Iroot decreases exponentially with soil depth, and the top 20 cm soil contains >60% of total Iroot. Actual C input contributing to long-term bulk soil storage (i.e., Iroot – Iloss) shows a similar depth distribution to Iroot. We also map Iloss and its depth distribution across the globe. Our results demonstrate the global significance of direct C losses which limit the contribution of Iroot to bulk soil C storage; and provide spatially explicit data to facilitate reliable soil C predictions via separating direct C losses from total root-derived C inputs. It should be noticed that cropland is a unique ecosystem that can be extensively managed and may have large potentials to sequester C. Focusing on China's cropland soil, we used a modelling approach and found that between 1980 and 2020, the average soil C at the top 30 cm in croplands increased from 40 Mg C ha-1 to 49 Mg C ha-1, resulting in a national carbon sequestration of 1,100 Tg C in total, constituting ~1/3 of the nation's annual anthropogenic C emissions. Increased organic C inputs, particularly from the straw return, was the crucial factor in soil C increase.

OS-013

Trajectory based simulation of collision-induced spectra

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Collision-induced absorption (CIA) is known to play an important role in the planetary atmospheres radiative balance [1,2]. By its physical origin, the CIA is closely related to the water vapor continuum absorption, which is largely responsible for the Earth's greenhouse warming. The CIA theoretical fundamentals were well understood by the middle of the last century. It is only recently, however, that the CIA theory free from adjustable parameters has been able to build up thanks to impressive advancement in the theoretical quantum chemistry and computer facilities. Also, the use of extremely sensitive spectroscopic tools enables nowadays laboratory CIA measurements with unprecedented accuracy.

In this report, brief survey is given of the CIA theory (see e.g. [3-5]) based on the classical scattering trajectories of some atmospherically relevant molecular pairs (N_2-N_2, N_2-Ar, CO_2-CO_2, CO_2-Ar, N_2-CH_4 etc.). Very accurate intermolecular potential energy and induced dipole surfaces issued from the dedicated quantum chemical calculations are employed without any adjustment. Our trajectory based approach differs significantly from other theoretical methods developed presently for the CIA simulation. The drawbacks and benefits of these methods are discussed.

Our main efforts are due to CIA simulation of the rototranslational spectra situated in the far-infrared and microwave spectral ranges. Overall good agreement among our calculations and available observations encourage extension of our approach to those molecular pairs and external conditions, the data for which are still missed. Recent results [5] obtained in assumption of the flexible N_2 moiety within the N_2-Ar molecular pair demonstrate applicability of our trajectory based formalism for the CIA simulation of the nominally electric-dipole-forbidden rovibrational bands.

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OS-014

Validation of Chinese CO2-measuring sensors and European TROPOMI/Sentinel-5 Precursor using FTIR and MAX-DOAS data at Xianghe (VCEX)

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An IFS125HR has been deployed in Xianghe Integrated Observatory. Long-term operations were carried out for accumulating high quality data, which is significant for validating the satellite greenhouse gases products and for finding the signal of climate change. Methane (CH4) is the second most important greenhouse gas after carbon dioxide. Accurate monitoring and understanding of its spatiotemporal distribution are crucial for effective mitigation strategies. At present, More than 5 years of data products of greenhouse gases such as CO2, CH4, N2O, H2O, HDO measured by the FTIR has archived in the Total Carbon Column Observing Network dataset. These data were widely applied to validate the satellite products of CO2, CH4 of on-orbit CO2-measuring satellites such as TROPOMI, TanSat, GOSAT 1/2, OCO 2/3, etc. The intercomparison of the satellite products using different TCCON sites shows the high quality of retrieving CO2 and CH4 column density data in Xianghe station. The validated greenhouse-measuring satellite data products as well as the ground-based FTIR measured carbon column density and profiles can be employed to feed carbon transport and carbon data assimilation models for retrieving the carbon emission sources and sinks, which is the most important study in China for achieving the ambitious goal of carbon peaking and carbon neutrality in 2060.

Key words: FTIR, TCCON, Carbon Dioxide, TROPOMI, MAX-DOAS

OS-015

Extratropical cyclones and their impact on ocean waves in the Northern Hemisphere

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Changes in extratropical cyclones and their impact on ocean waves are critical to the safety of maritime activities and coastal regions. These cyclones, with their extreme winds, can significantly affect the characteristics of ocean waves, posing risks to shipping, offshore and coastal infrastructure. Understanding the links between cyclones and ocean wave characteristics is essential for improving early warning systems, ensuring shipping safety, and better preparing coastal communities. Based on the ERA5 reanalysis data for 1940-2023, this study examines changes in the extratropical cyclone characteristics in the Northern Hemisphere winter and summer over oceans, focusing on the Atlantic, Pacific, and Arctic Oceans. In winter, cyclone frequency trends show a decrease in the Atlantic and Pacific Oceans and an increase in the Arctic Ocean. In summer, cyclone frequency trends show an increase in all regions. Intense cyclones increase over the Pacific and Arctic Oceans in winter and over the Arctic Ocean in summer. The relative contribution of cyclones to ocean waves' formation is also assessed in terms of significant wave height (SWH). The most intense cyclones are responsible for forming the highest ocean waves, contributing more than 30% of the extreme values. Intense cyclones play a crucial role in creating extreme SWH, especially in winter, accounting for up to 90% of the extreme values. An analytical expression is derived to estimate the maximum SWH induced by a cyclone using the cyclone's depth and size. The SWH values calculated by the analytical expression agree with those from ERA5.

Cyclone characteristics were calculated within the Russian-Chinese project № 23-47-00104 from RSF and 42261134532 from NSFC. The relationship of ocean waves with the cyclone activity was analyzed within the RSF project 24-17-00211.

OS-016

Lidar studies of the middle atmosphere in the polar region

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This talk aims to review the lidar performances in the Antarcitic and Arctic region for measuring the temperature, density, wind, polar mesospheric clouds, and metal layers in the middle atmosphere. Technical challenges will be discussed for lidar based on resonance scattering, Rayleigh scattering, Mie scattering, and Doppler shift principles. Related scientific outcomes will also be presented.

OS-017

Emission ratios of trace gases and ozone production in Siberian forest fire plumes

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Atmospheric emissions from boreal forest fires may affect regional air quality and Arctic climate, contributing to haze events and warming. Ozone, which is produced in troposphere from biomass burning products, is harmful for humans and plants, affects chemical processes and alters lifetime of other gases in troposphere. Wildfire activity in Siberia increases in recent decades due to climate change and anthropogenic exposure, while the composition of wildfire emissions is poorly known. We report emission ratios (ERs) for trace gases released by wildfires, which represent the amount of gas emitted divided by the corresponding amount of a reference gas. The ERs are necessary to calculate the mass of gas released into the atmosphere due to combustion of a known mass of fuel. Our estimates are based on near-ground observations of carbon oxides (CO_2, CO), methane (CH_4), nonmethane hydrocarbons (NMHC), nitrogen oxides (NOx = NO + NO_2), and ozone (O_3) obtained from railway TROICA expeditions in years 2005 and 2007 [1] and at ZOTTO observatory in severe wildfire years 2011 and 2012 [2]. The reported ERs suggest higher emissions of CO, CH_4, and NMHC from smoldering combustion and much lower emissions of NOx from flaming combustion compared to the known estimetes for wildfires in North America. The estimated O_3 levels are typical for forest fire plumes of 1–2 days old observed in the middle and circumpolar latitudes. The uncertainties 5–20% of the reported ERs are not higher than in other studies and arise from the uncertainty of measurements (minor), the uncertainty linear regression estimates, and natural variability (major).

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OS-018

Size-resolved microphysical and optical properties of atmospheric aerosols in an urban area of the northern Tibetan Plateau

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Aerosols at high altitudes on the Tibetan Plateau significantly impact regional climate and hydrological cycles. This study investigates the size-resolved microphysical and optical properties of atmospheric aerosols in an urban area of the northern Tibetan Plateau using a ground-based tandem system comprising a differential mobility analyzer, a condensation particle counter, and a single particle soot photometer. The average particle number size distribution (PNSD) exhibits a lognormal distribution with a peak diameter around 70 nm. Approximately 17.7% of particles within the mobility diameter (Dmob) range of 100-750 nm contain refractory black carbon (rBC), with the fraction increasing to over 50% for particles with Dmob > 500 nm. Most rBC-containing particles are externally mixed with other components, and only 12.2% have thick coatings. Externally mixed rBC particles exhibit high non-sphericity, with the dynamic shape factor increasing from 1.8 at 115 nm Dmob to 2.8 at 750 nm Dmob, indicating aggregate structures. Thickly coated rBC particles are near-spherical, with coating thickness increasing with Dmob. The total rBC mass estimated from size-resolved measurements aligns well with the bulk rBC mass directly measured. The refractive index (RI) of rBC-free particles has a mean value of 1.40 at the wavelength of 1064 nm, with little variation in the 200-500 nm Dmob range. The low RI is likely due to the dominant contribution of organic matter in fine particles. The light enhancement for rBC particles is estimated to have a mean of 1.1, owing to the low fraction of thickly coated rBC particles.

OS-019

Lightning leader propagation and its effects

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Lightning propagates as a bipolar bidirectional leader tree in the cloud, and there is an asymmetry in the propagation manners of two ends. The positive ends show a smooth propagation with few radiations, while the negative ends present a stepped branching manner and produce apparent wideband radio frequency radiations. Positive leaders tended to decay and reactivate, while negative leaders were once believed to be never reactivated. Recent observation revealed that the decayed negative branches can be reactivated, but such a reactivation along the decayed branch experienced a reversal of the breakdown polarity. Similarly, the positive leader branches can also have side discharges with reversal breakdown polarity, called needle discharge. Besides, a floating bidirectional leader can be excited near a progressing positive leader, with the negative end approaching the parent positive channel and making a connection. The outward negative breakdown of needle discharge from the positive main channel and the approaching negative end of the floating bidirectional leader can sometimes coexist. It is hard to imagine how two negative breakdowns get approached. Here, we proposed an unequal-potential lightning propagated mode to explain all these new phenomena. Our results indicate that lightning channels can develop in an unbalanced manner that favors the sustainment of an established lightning channel.

OS-020

Convective and electrostatic components of dust aerosol emission

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The most studied mechanism of dust aerosol generation as a result of large particle (~100 μm) hopping saltation over the underlying surface of arid territories is wind transport. Dust transport models use parameterizations associated with estimates of the saltation flux intensity near the surface at wind velocities exceeding critical values [1] (~5m/s).

In the course of long-term complex field studies of the A.M.Obukhov Institute of Atmospheric Physics of the Russian Academy of Sciences [2-4], additional factors significantly affecting dust aerosol emission were revealed.

1. Relation of the dust aerosol mass concentration value with the vertical temperature gradient (heat fluxes) in the near-surface air layer during intensive surface heating [2]. The convective upward motions in the surface layer is significant occurrence at low wind speeds (<4 m/s). The height of hopping of the saltation particles changes at higher wind speeds (>6 m/s). Universal power-law profiles of height distribution for dust aerosol concentration with slopes of -0.5 (weak wind), -1 (strong wind) are observed [5].

2. The electric field strength acquires negative values at high wind velocities [6]. The value of the electric field strength as well as the size distribution of dust aerosol particles changes at prevailing wind directions close to the lines of dune ridges [7]. This is determined by the mechanism of particle charging [8] as a result of capture of a larger fraction from the leeward slope zone.

3. High-frequency measurements of wind temperature and velocity (1000 Hz), electric field strength (100 Hz), and dust aerosol concentration (10 Hz) revealed wind-borne vertical structures through the sensors [9]. Thus, dust aerosol is lifted by thermal structures, supporting the emerging localized warmer regions as a result of heat transfer. As a result, the dust aerosol concentration field has structures similar to those observed in the temperature field. The electrical charge of dust particles also affects the development of structures.

For the spectra of temperature, velocity, concentration, and electric field strength, in addition to the known slope of -5/3, other slopes -1, -3, and -1/3 (related to convective processes) are noted.

In general, convection in the near-surface layer during hot weather, as well as the charge of the dust aerosol, have a significant influence on the amount of its removal and long-range transport.

This work was supported by the Russian Science Foundation (project № 20-17-00214).

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OS-021

Turbulent flux transfer over the Dunhuang Gobi surface

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The arid region of Northwest China, characterized by scarce precipitation and the land surface dominated by deserts, Gobi, and sparse vegetation, experiences intense land-atmosphere interactions and is therefore is one of the region with strongest sensible flux in the Eurasian continent. This study focuses on the characteristics of turbulent flux transfer on the typical Gobi surface in the Dunhuang area, a typical arid region within Northwest China. The research is based on multi-year land surface process observation data, especially turbulence observation data, from the Dunhuang Gobi station. The results indicate that the near-surface energy closure ratio reaches around 0.9. The sensible heat flux generally dominates in the near ground energy budget, while the latent heat flux is often negligible. The sensible heat flux in spring and summer (especially from April to August) markedly exceeds that in autumn and winter, with multiyear average values reaching 65 and 78 W m-2, respectively. Corresponding to the strong sensible heat transfer from the surface, a deep boundary layer is present in the spring and summer, with the highest reaching over 4800 m. Moreover, the momentum roughness of the Gobi surface is determined at the 1 mm scale, and the thermal roughness is an order of magnitude smaller than the momentum roughness. Comparisons with reanalysis data show that there is considerable uncertainty in the sensible heat flux, which is closely related to the momentum roughness and thermal parameterization schemes. These findings will be beneficial for further understanding the variations in turbulent heat fluxes in the arid regions of Northwest China, as well as their climatic impacts on East Asian Monsoon.

OS-022

Characteristics of the inertia gravity waves and turbulence parameters in the troposphere and lower stratosphere revealed by the MST radar observations

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The Beijing MST Radar (39.78°N, 116.95°E) was put into routine operation in late 2011. High-quality horizontal wind, vertical velocity spectral width data, etc., were obtained by improving the power spectral density data processing algorithm. Based on these valuable data sets, new cognition in the aspects of gravity waves and turbulence characteristics in the mid-latitude was obtained. The Inertia-gravity Waves (IGWs) parameters show dependence on both heights, months, and vertical propagating directions, indicating that wave sources are complicated in the area represented by radar observations. Among the plausible candidates for the IGWs wave sources, such as topography, subtropical westerly jet, shear instabilities, etc., vertical shear of horizontal wind was proven to be essential. The turbulence energy dissipation rate ε and the vertical turbulence diffusion coefficient Kz in the troposphere–lower stratosphere over the radar site are revealed. It is found that the seasonal variation of turbulence parameters has noticeable differences at different atmospheric layers. Furthermore, the atmospheric static/dynamic stability and turbulence intensity are the influencing factors of turbulence parameters.

OS-023

AI assists the development of meteorological observation equipment

Zhaorui Li

ZOGLAB Microsystem Co., Ltd.

Visibility measurements play a vital role in meteorology, aviation, transportation and environmental monitoring. Accurate assessment of visibility conditions is critical to ensuring safety, especially where visibility can significantly impact the decision-making process.

Traditional visibility measurement methods include manual observation and observation using transmissometers, which estimate visibility by measuring light attenuation due to atmospheric particles.

With the advancement of technology, modern technology now integrates LiDAR (Light Detection and Ranging), cameras and even remote sensing technology to provide more accurate and real-time data.

A recent development is the integration of artificial intelligence (AI) and machine learning algorithms into visibility measurement systems. These systems use historical data and current atmospheric conditions to more accurately predict visibility levels. Innovations in visibility measurement technology not only improve operational efficiency, but also promote public safety and environmental awareness. As technology continues to advance, future visibility measurements will show higher accuracy, reliability and wider application in various fields.

OS-024

Nighttime Aerosol Optical Thickness Remote Sensing Based on Starlight Observations

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Aerosols, as a crucial component of the Earth's atmosphere, have a significant impact on climate change, ecological environments, and human health. The Intergovernmental Panel on Climate Change's Sixth Assessment Report emphasizes that aerosols remain the most uncertain component in climate system assessments. This highlights our current low level of understanding of aerosols, making real-time and effective detection of aerosols crucial. Currently, detection methods are mostly limited to daytime, leading to a lack of nighttime aerosol information. However, aerosols are influenced by human activities and meteorological conditions, exhibiting rapid spatial and temporal variations, often with distinct diurnal changes. Therefore, developing nighttime aerosol observations to obtain continuous aerosol information day and night is urgently needed. In this study, nighttime starlight observations were conducted in Beijing using an astronomical telescope, CCD camera, and a filter wheel composed starlight photometer. Aerosol optical thickness during nighttime was inverted from these observations. The results were compared and analyzed against visibility meter data and moonlight remote sensing data provided by AERONET. The findings indicate that starlight remote sensing can provide accurate nighttime aerosol information. Moreover, starlight, compared to moonlight, serves as a more stable radiation source, holding the potential to become a primary method for future nighttime ground-based aerosol remote sensing.

OS-025

Correction of satellite datasets to improve the orbital and ground-based data compliance parameters and to clarify the atmospheric composition trend estimates

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The work is dedicated to the validation of the satellite product total content (TC) CH_4 (TotCol CH_4) AIRS v6 (IR-AIRS Only) with the data from 12 ground-based spectrometers of the Network for the Detection of Atmospheric Composition Change (NDACC) for the ~~time~~ period ~~of~~ 2003 – 2022.

The aim of the work was to develop a universal method for correcting orbital data, thereby improving the consistency of orbital measurements with ground-based data and increasing the accuracy of estimates of trends in the composition and parameters of the atmosphere.

It was found that for CH_4-TC the linear trend of the difference between AIRS and corresponding ground-based data (AIRS-GR) has a negative value at all stations studied, and the slope of this trend is close in magnitude. The effect observed indicates a drift in the satellite spectrometer parameters, which requires a correction of the AIRS data and subsequent comparisons to assess the quality of the result obtained.

It is worth noting that the satellite instrument systematically underestimates the absolute values and thus the trend estimates (by a factor of about 1.5) at all the sites studied, compared with the results obtained from ground observations.

To correct the AIRS data for CH_4 TC, the average slope coefficient of the linear trend difference (Satellite Spectrometer Drift or SSD) based on all statistically ensured stations (12 stations) was calculated to be 1.72E+14±3.02E+13 molec/cm^2 per day (in absolute units). (see Table 1).

Table 1. Linear regression slope coefficient and ±95% confidence interval for the AIRS-GR difference in TC CH_4 for each measurement site

№	Measurement site	Slope of the difference trend, molec/cm^2	№	Measurement site	Slope of the difference trend, molec/cm^2
1	Kiruna	-1,34E+14±1,54E+13	7	Toronto	-1,43E+14±2,96E+13
2	Harestua	-1,98E+14±4,50E+13	8	Izana	-1,33E+14±1,48E+13

3	SPB	-2,18E+14±3,02E+13	9	Mauna Loa	-2,14E+14±4,63E+13
4	Bremen	-2,42E+14±2,97E+13	10	Reunion	-2,54E+14±5,64E+13
5	Zugspitze	-1,75E+14±2,76E+13	11	Wollongong	-8,13E+13±1,67E+13
6	Jungfraujoch	-1,40E+14±3,27E+13	12	Lauder	-1,37E+14±1,81E+13
	AVERAGE	**-1,72E+14±3,02E+13**			

The dynamic correction of the satellite data has been carried out from 01 January 2003 using the average coefficient obtained as follows:

TC CH_4 SSD = TC CH_4+(N-1)*SSD, where:

TC CH_4 SSD – adjusted daily satellite value of TC CH_4, molec/cm^2

TC CH_4 – total CH_4 content, molec /cm^2 AIRS V6 L3

N – the ordinal number of the day, starting from 01/01/2003

SSD – satellite spectrometer drift, 1,72E+14 molec/cm^2.

The correlation parameters and trend estimates of the average daily values of the TC CH_4 of the AIRS orbital instrument and the NDACC ground-based spectrometers before and after correction were compared. The results show that it is possible to achieve a significant improvement in the fit of both parameters can be obtained using the developed method.

Thus, an increase in the correlation coefficient R is observed at all stations after the application of the dynamic correction, even at those sites where the correlation was initially high. The relatively low correlation (R~0.4–0.5) observed in the original series of four high-altitude stations (Zugspitze, Jungfraujoch, Mauna Loa and Reunion Maido) increased to R~0.5-0.6 after the correction. At the lowland stations, as well as at the station Izana, the correlation increased to R~0.7–0.9.

In addition, the discrepancy between the estimates of TC CH4 trends obtained using the adjusted orbital series and those based on ground measurements became significantly smaller for each station individually and practically coincided on average for all stations: AIRS: 0.45±0.03%/yr; GR: 0.43±0.02%/yr compared to the initial AIRS estimate of 0.29±0.03%/yr.

The methodology developed for comparing and correcting orbital data is applicable to any long-term satellite observations.

This work was carried out with the support of the Russian Science Foundation, project no. 20-17-00200.

OS-026

How can finer resolution of General Circulation Model improve the precipitation simulation in China?

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The formation of precipitation is closely related to circulation on different scales, some of which are strongly affected by orography. Considering the huge cost of high-resolution simulation globally, the horizontal resolution of atmospheric General Circulation Models (AGCM) that participated in CMIP campaigns is generally 1°-2°. The relatively coarse resolution could lead to large biases in precipitation simulation, especially in China where many types of precipitation are impacted by the complex orography, such as monsoon rainband and high-altitude rainfall. Here, the effects of increased horizontal resolution of GCMs on the rainfall simulation of Mei-yu band and on the Tibetan Plateau are addressed through moisture budget analysis, moist static energy diagnosis, et al. Finer resolution in AGCMs can significantly improve the dry biases in Mei-yu band simulation through enhancing the convergence of meridional moisture flux or increasing the surface latent heat flux over the nearby seas. Meanwhile, the wet biases over the Tibetan Plateau can also be improved through suppressing evaporation due to reduced surface wind speed and through enhanced rain shadow effect because of sharper orography between summit and valley is resolved. Compared with the low resolution, high-resolution GCMs can also show a different rainfall projection in Mei-yu region because the western North Pacific Subtropical High is relatively steady with climate change in high-resolution model whereas it weakens and retreats eastwards evidently in the low one. Our studies emphasize the necessity of high-resolution simulation and projection in understanding the orographic effect on precipitation and addressing climate change.

OS-027

Spatiotemporal evolution of the Arctic sea ice in the 21st century according to observations and CMIP6 models

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The changes in the Arctic sea ice area are studied using the CMIP6 and DCPP model ensembles, as well as the ERA5 reanalysis data for the period 1980–2030. The ensemble mean changes for the CMIP6 ensemble, representing the response to external climate forcing, show a close to linear negative trend for the period 1980–2030, and do not reproduce the acceleration of sea ice retreat in the early 20th century. The DCPP models showed a significantly better agreement with the observational data, including reproducing the acceleration of ice melting in March at the beginning of the 20th century.

The record minimum September sea ice area 2012 is also analyzed, alone with analogous minima in climate models during the same period. It is found that both observed and simulated sea ice minima are related to a specific atmospheric circulation pattern in preceding August – pressure dipole with a cyclone over the Arctic Ocean and anticyclone over the northern North Pacific. It is suggested that this circulation pattern fostered an accelerated sea ice melt both dynamically and thermodynamically.

OS-028

Assessing the impacts of carbon neutral pathways on photovoltaic power generation in China

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With China's commitment to achieving carbon peaking and carbon neutrality, it is explicitly stated that the proportion of non-fossil energy should surpass 80%. Against this backdrop, previous research has primarily focused on the impact of climate policies in mitigating climate change but has yet to conduct a systematic evaluation of solar energy variations under realistic carbon-neutral pathways. This study employs simulations based on actual carbon-neutral scenarios, utilizing WRF-chem and a photovoltaic physical model chain to calculate radiation and photovoltaic output variations under different pathways. The findings indicate that the process of increasing photovoltaic capacity leads to a reduction in greenhouse gas and particle emissions, thereby inducing changes in the climate system. Then, surface solar radiation increases, resulting in an additional positive effect that enhances photovoltaic power output. This positive benefit holds significant importance in the promotion of non-fossil energy.

OS-029

Electric field-meteorological integrated sounding and the charge structure of thunderstorms in North China

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Electric field and charge structure of thunderstorms is an important content in atmospheric electrical research. The double-metal-sphere three-dimensional electric field sonde was developed and a series of integrated electric field and meteorological parameters were captured. It was found that, for the weak echo region of a mesoscale convection system which was at the mature stage, there were five charge regions in the thunderstorm and the charge polarity altered in the vertical direction, and more charge layers were in cloud. The sounding system experienced the stages of rising, falling and rising again during 3.6-4.4 km, which were in the range of the middle negative region. The regional charge structures of the three stages were similar but different, which reflected the real charge structure inside the thunderstorm was very complicated and inhomogeneous spatio-temporally. For the edge region of a single-cell storm at the mature stage, there are only two obvious charge layers near the 0 ºC layer. Different soundings show that the charge structure in thunderstorm varies with the type of thunderstorm, the development stage, and the sounding-passed region.

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OS-030

The decomposition of complex acoustic atmospheric signals into specific shapes

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In this paper, we present a mathematical model for the recorded infrasound signal. The signal is composed of a sum of N- and U-waves [1] with known shapes that are shifted relative to each other over certain time intervals and a noise component. The goal is to estimate the number of waves in a signal, the coefficients for the linear combination of these waves, and the time delays between them. We assume that the noise is white Gaussian with a specified variance.

The solution method involves two stages. In the first stage, we assume that the recorded signal can be represented as a sum of individual waves. Then, using the methods of the theory of measuring and computing systems [2], the best estimate of the vector of the coefficients of a linear combination is constructed.

In the second stage, we select the coordinates of the vector whose modulus exceeds a specified threshold. Coordinates whose modulus is below the threshold are set to zero. This filtering process allows us to extract the most significant components of the N-and U-infrasound signals.

The report provides examples of how real signals can be decomposed into a linear combination of N- and U-waves. This demonstrates the effectiveness of the proposed method. By knowing the arrival times of these waves, we can evaluate the structure of the horizontally homogeneous atmosphere [3].

This work was carried out according to the state task with the support of the Ministry of Science and Higher Education of the Russian Federation (Topic 17.1 and Topic FMWR-2022-0017).

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OS-031

The Potential Impact of Blue Jet Discharge on Stratospheric Chemistry Using a Detailed Plasma-Chemistry Model

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Blue jet (BJ) is a type of upper atmospheric discharge which produces nitrogen oxides (NOx = NO + NO2) through the same chemical reactions as the tropospheric discharges. As stratospheric NOx contributes to ozone depletion and BJ occurs at the altitude of the stratospheric ozone layer, this study estimates its chemical effects in the stratosphere using a detailed plasma-chemistry model, focusing on the chemical families of oxygen, nitrogen, chlorine, and bromine. Results show that ozone in the mid-stratosphere increases during the first 100 s, but there are no significant changes in the lower or upper stratosphere. However, after 2 days of simulation, BJ causes changes in nitrogen oxides, chlorine, and bromine that results in ozone depletion in the middle and upper stratosphere. The changes in the chemical system persist as the chemicals involved have long lifetimes in the stratosphere. The ozone layer also shifts to a lower altitude with less abundance. This study explores the chemical effect of transient luminous events at higher altitudes.

OS-032

Stratospheric aerosol variability over Tibetan Plateau

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Stratospheric aerosol plays an important role in atmospheric radiation and stratospheric chemistry. Based on balloon data and numeric simulations with aerosol sectional model, we found that stratospheric aerosols show high variability in the layer of 15-20 km but low variability above 20 km over Tibetan Plateau (TP). Numeric simulations suggest that volcanic eruptions and extreme wildfires could explain 50% stratospheric aerosol variance over TP. Background stratospheric aerosol variability over TP is mainly regulated by seasonal cycle. Furthermore, our results pointed out that there are abundant organic aerosols (OAs) at altitude of 15-20 km but limited OAs above 20 km, which indicates that the tropospheric aerosols could not be uplifted above 20 km and leads to low stratospheric aerosol variability above 20 km.