ISDA-Online

Friday, May 03, 2024 from 7-9h UTC

"Topic: Predictability"

Organizers*:* Monika Krysta *(BoM, Australia),*
Takeshi Enomoto *(Kyoto U., Japan),*
Tobias Necker *(U. Vienna, Austria)*

Invited Speaker: Prof. Dr. George Craig *(HErZ / LMU Munich, Germany)*

Join us for a compelling session on Predictability, focusing on its limits and the potential for enhancement through improved Data Assimilation. This session targets the core questions: How far can we stretch the boundaries of Predictability? And in what ways can refining data assimilation techniques contribute to this expansion? The session will navigate the intricate interplay between the inherent limits of forecasting and the advances in data assimilation, crucial for example in meteorology, oceanography, or seismology. We invite abstracts for a vibrant exchange of ideas aimed at deepening our understanding of Error Growth and Predictability in environmental and chaotic systems.

Program:

07:00 – 07:05	**Welcome**
	(45min invited talk / keynote + 10min Q&A)
07:05 – 08:00	**The Limits of Predictability** George Craig, Tobias Selz
	(15min short talks + 3min Q&A each)
08:00 – 08:18	**Impacts of Mountain Topography and Background Flow Conditions on the Predictability of Thermally Induced Thunderstorms and the Associated Error Growth** Pin-Ying Wu, Tetsuya Takemi
08:19 – 08:37	**Improved subseasonal prediction of South Asian monsoon rainfall using data-driven forecasts of oscillatory modes** Eviatar Bach, V. Krishnamurthy, Safa Mote, Jagadish Shukla, A. Surjalal Sharma, Eugenia Kalnay, Michael Ghil
08:38 – 08:56	**Ensemble sensitivity analysis for high-impact weather** Takeshi Enomoto, Saori Nakashita
08:57 – 09:00	**Closing / Outlook**

Please note:

- The times in UTC are approximate.
  In case of technical problems, we might have to change the order of the presentations.
- **Time Zones**: **07 – 09 UTC**
  08 – 10 am BST (London) | 09 – 11 am CEST (Berlin)
  03 – 05 pm CST (Shanghai) | 04 – 06 pm JST (Tokyo) | 05 – 07 pm AEDT (Sydney)
  00 – 02 am PDT (San Fran.) | 01 – 03 am MDT (Denver) | 03 – 05 am EDT (New York)
- **How to attend to ISDA-Online events?**
  Simply subscribe to the ISDA-Online mailing list or visit our website

The Limits of Predictability

George Craig[1], Tobias Selz[1]

LMU Munich, Germany

In this presentation, I will briefly review some recent results on the predictability of the atmosphere. The focus will be on:

1. What determines the intrinsic predictability limit for medium-range forecasting in the midlatitudes? and,
2. How much room for improvement do we have with better models and better initial conditions?

Finally I will examine the ability of some recent machine learning models to accurately represent the limits of predictability, and conclude with a few remarks on how predictability is different in the tropics, at convective scales and on seasonal to subseasonal timescales.

Impacts of Mountain Topography and Background Flow Conditions on the Predictability of Thermally Induced Thunderstorms and the Associated Error Growth

Pin-Ying Wu[1], Tetsuya Takemi[2]

[1] Meteorological Research Institute, Japan
[2] Kyoto University, Japan

Thermally induced thunderstorm simulations were conducted with the Weather Research and Forecasting (WRF) Model in an idealized configuration to investigate the associated error growth and predictability. We conducted identical twin experiments with different topography and background winds to assess the impacts of these factors. The results showed that mountain topography restrains error growth at the early stage of convection development. This topographic effect is sensitive to mountain geometry and background winds: it was more noticeable in cases with higher and narrower mountains and difficult to see without background wind. The topographic effect and its sensitivity resulted from the different natures of convection initiation. However, the topographic effect became less apparent when moist convection continued growing and triggered rapid error growth. The predictability of thunderstorms is then limited at the timing after the convective activity reached its maximum. A smaller initial error or starting a simulation at a later time did not break this timing of predictability limit. Mountain topography also limitedly affected the timing of the maximum convective activity and the predictability limit. In contrast, background flows changed the convection evolution and the following predictability. The predictability limit assessed by rainfall suggested other aspects of the topographic effect. The domain scale rainfall distribution and the intense accumulated rainfall can be adequately captured in the presence of mountains.

Improved subseasonal prediction of South Asian monsoon rainfall using data-driven forecasts of oscillatory modes

Eviatar Bach *(California Institute of Technology, US)*
V. Krishnamurthy *(George Mason University)*
Safa Mote *(Portland State University)*
Jagadish Shukla *(George Mason University)*
Surjalal Sharma *(University of Maryland, College Park; deceased)*
Eugenia Kalnay *(University of Maryland, College Park)*
Michael Ghil *(University of California, Los Angeles and École Normale Supérieure)*

Predicting the temporal and spatial patterns of South Asian monsoon rainfall within a season is of critical importance due to its impact on agriculture, water availability, and flooding. The monsoon intraseasonal oscillation (MISO) is a robust northward-propagating mode that determines the active and break phases of the monsoon, and much of the regional distribution of rainfall. However, dynamical atmospheric forecast models predict this mode poorly. Data-driven methods for MISO prediction have shown more skill, but only predict the portion of the rainfall corresponding to MISO rather than the full rainfall signal.
Here, we combine state-of-the-art ensemble precipitation forecasts from a high-resolution atmospheric model with data-driven forecasts of MISO using a novel method. The ensemble members of the detailed atmospheric model are projected onto a lower-dimensional subspace corresponding to the MISO dynamics, and are then weighted according to their distance from the data-driven MISO forecast in this subspace. We thereby achieve improvements in rainfall forecasts over India, as well as the broader monsoon region, at 10--30 day lead times, an interval that is generally considered to be a predictability gap. The temporal correlation of rainfall forecasts is improved by up to 0.28 in this time range. Our results demonstrate the potential of leveraging the predictability of intraseasonal oscillations to improve extended-range forecasts; more generally, they point towards a future of combining dynamical and data-driven forecasts for Earth system prediction and data assimilation.

Ensemble sensitivity analysis for high-impact weather

Takeshi Enomoto[1], Saori Nakashita [2]

[1] Disaster Prevention Research Institute, Kyoto University/Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Japan
[2] Graduate School of Science, Kyoto University, Japan

The sensitivity analysis provides a valuable tool for investigating atmospheric predictability. It helps to identify the area or variables at the initial time that significantly influence the phenomena of interest at the verification time. This technique has been employed for targeted observations and for identification of the source of forecast errors. The ensemble sensitivity analysis eliminates the need for the adjoint of the forecast model and serves as a low-cost alternative to the adjoint-based analysis–forecast system. In this approach, the pre-run ensemble forecast may be used.
The ensemble singular vector (Bishop and Toth 1999, Zhang et al. 2016) and adjoint (Ancell and Hakim 2007, Ancelland Coleman 2022) sensitivities can be derived using the Lagrange multiplier method (Enomoto et al. 2015). Notably, the ensemble sensitivity analysis exhibits a wide applicability despite the assumption of linearity. It allows us to identify the sensitivities not only for extratropical cyclones but also for tropical cyclones. This success is partly attributed to the ensemble forecasts generated using a nonlinear model. Sensitivity can be verified by perturbed forecasts with a nonlinear model, which typically aligns with the linear sensitivity but also reveals asymmetry in perturbations of opposite signs. Furthermore, the ensemble singular vector contributes to additive inflation (Yang et al. 2015, Shin et al. 2019) and enhances balance (Ota and Hotta 2016) in local ensemble transform Kalman Filter (LETKF) by selecting fast-growing modes. These applications underscores the value of ensemble sensitivity in predictability studies.