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Upscale impact of diabatic processes from convective to near-hemispheric scale

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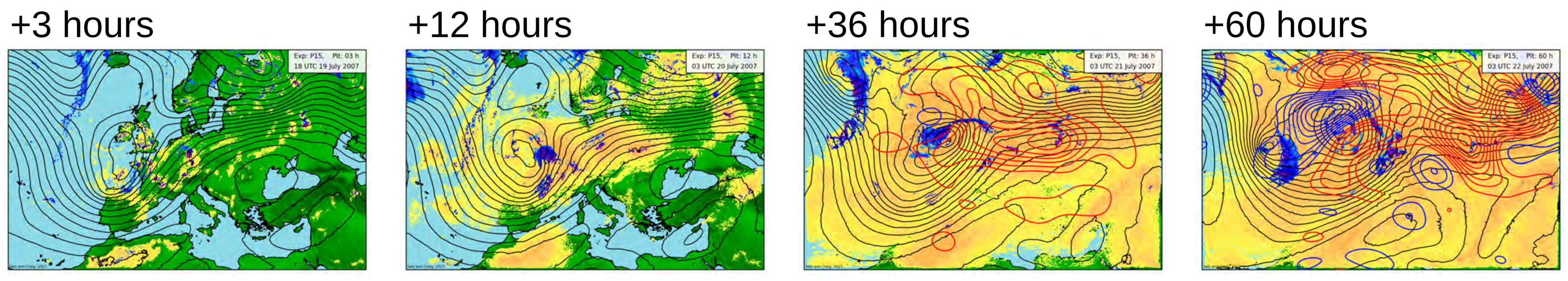
Three stage error growth concept (Zhang et al., 2007)

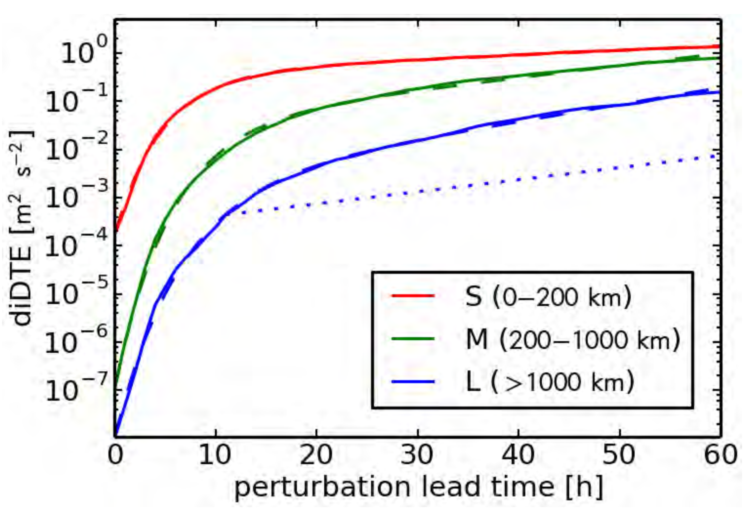
1) Convective instability and saturation (0 - 12 h)
2) Transition and geostrophic adjustment (8 - 24 h)
3) Large-scale baroclinic growth (> 24 h)

Convection permitting simulations

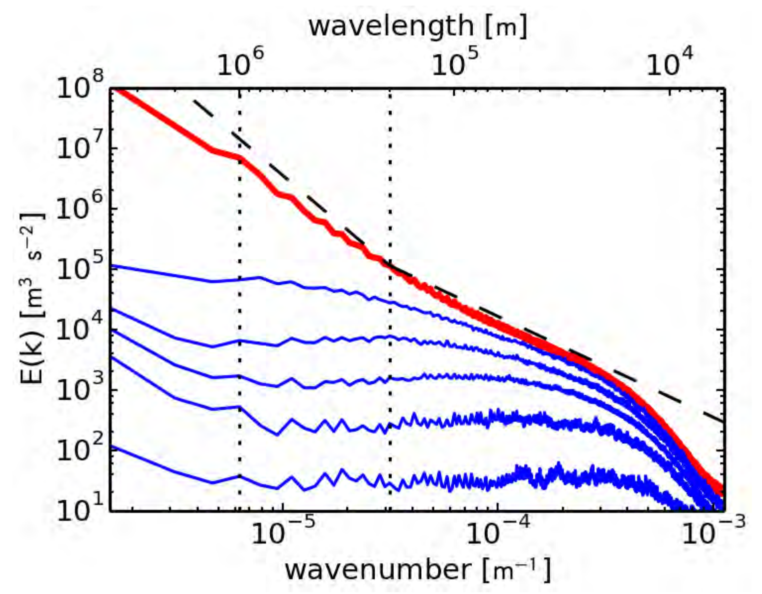
The COSMO model was used to study the three-stage concept on a summertime weather event over Europe (Selz and Craig, 2015a).



Development of a balanced synoptic-scale perturbation from fast error growth in convective instability. Black lines show 500 hPa geopotential, blueish shading precipitation rate of the unpertrubed run. Yellow shading show difference total energy (DTE) and red/blue contours 500 hPa geopotential difference between perturbed and unperturbed run.



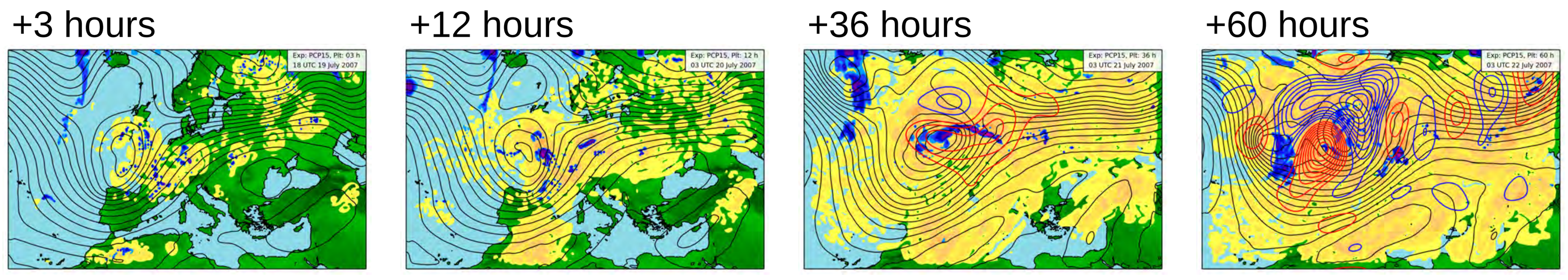
Development of domain-integrated difference total energy (diDTE), separated by scale.



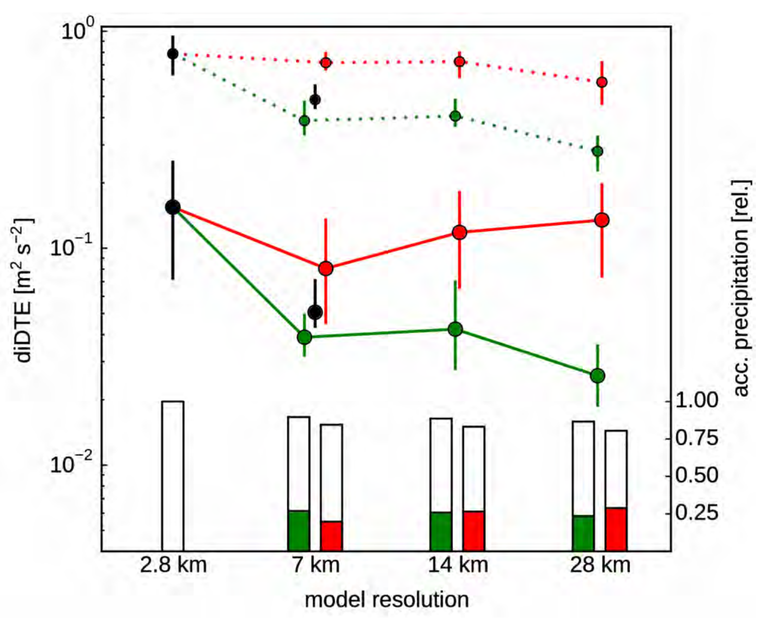
Kinetic energy spectra of the difference wind (blue) at several perturbation lead times. The averaged total spectrum is given in red.

Simulations with stochastic convection scheme

COSMO simulations on coarser grids with different convection schemes were compared to the high-resolution results (Selz and Craig, 2015b).



Development of a balanced synoptic-scale perturbation with 28 km resolution from a seed change of the stochastic convection scheme, which led to a different realization of the cloud ensembles in the grid boxes. Lines and colors as above.



The figure shows domain-integrated difference total energy (diDTE) after 60 h at large scales (solid lines) and at medium scales (dotted lines) as a function of resolution. Red indicates Plant-Craig (PC) scheme simulations, green Tiedtke simulations and black simulations without a deep convection scheme. The bars at the bottom show accumulated precipitation.

The Plant-Craig stochastic convection scheme can be used to simulate the effect of upscale error growth from convection on larger scales without the need to resolve the convection.

References

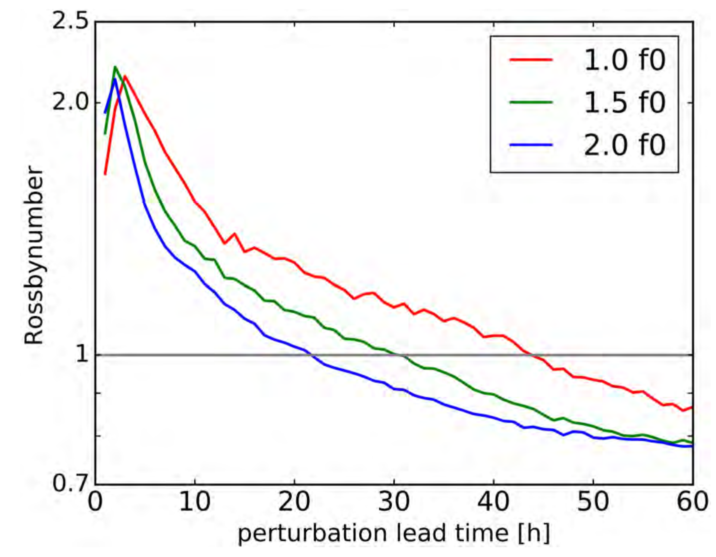
Zhang, Fuqing, et al., 2007: Mesoscale predictability of moist baroclinic waves: Convection-permitting experiments and multistage error growth dynamics. *Journal of the Atmospheric Sciences* **64**, 3579-3594.

Selz, Tobias, and George C. Craig, 2015a: Upscale Error Growth in a High-Resolution Simulation of a Summertime Weather Event over Europe. *Monthly Weather Review* **143**, 813-827.

Selz, Tobias, and George C. Craig, 2015b: Simulation of upscale error growth with a stochastic convection scheme. Geophysical Research Letters **42**, 3056-3062.

Idealized convection permitting simulations

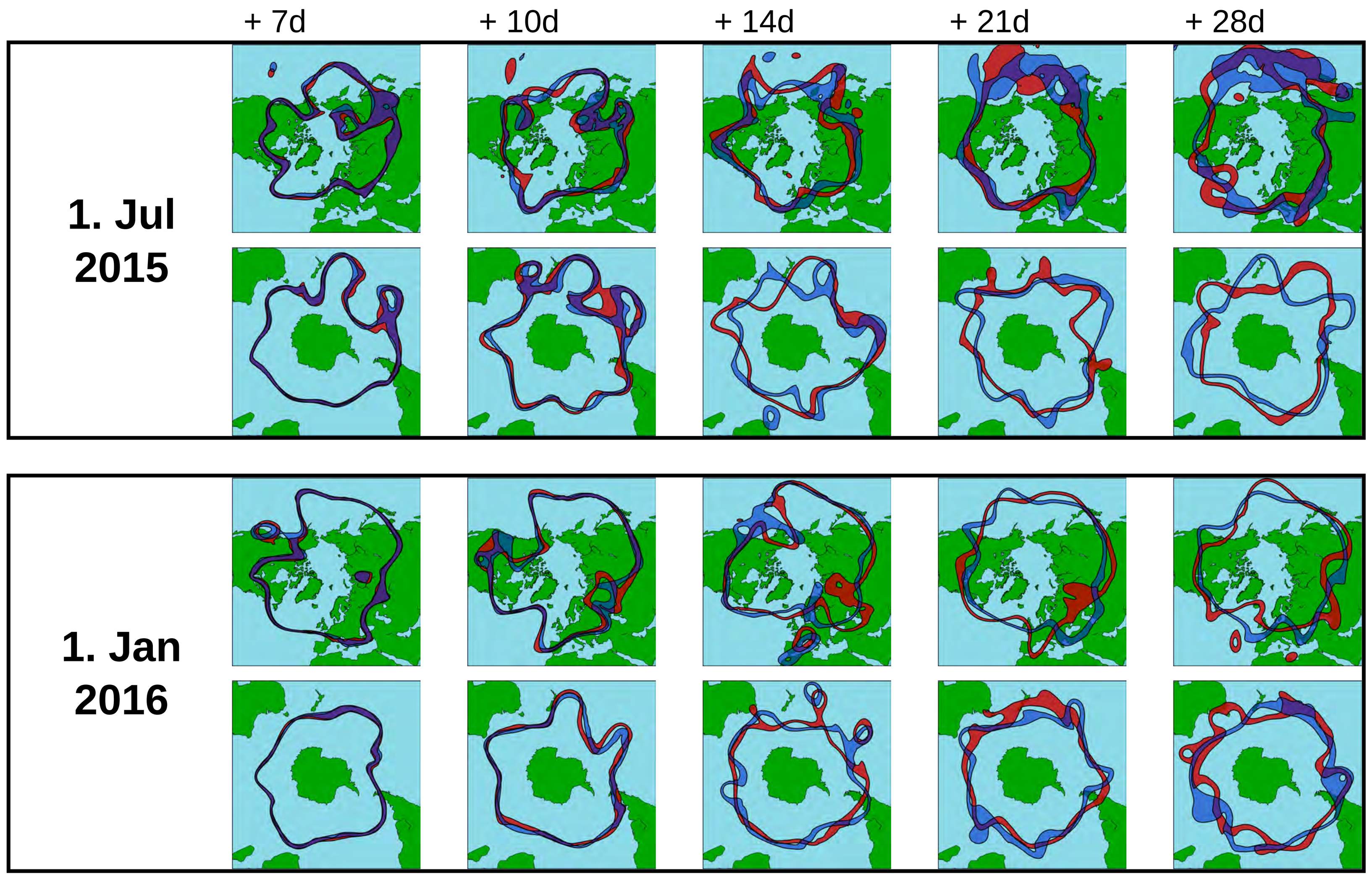
The hypothesized Coriolis parameter dependence of the three stage concept was tested with idealized COSMO simulations.



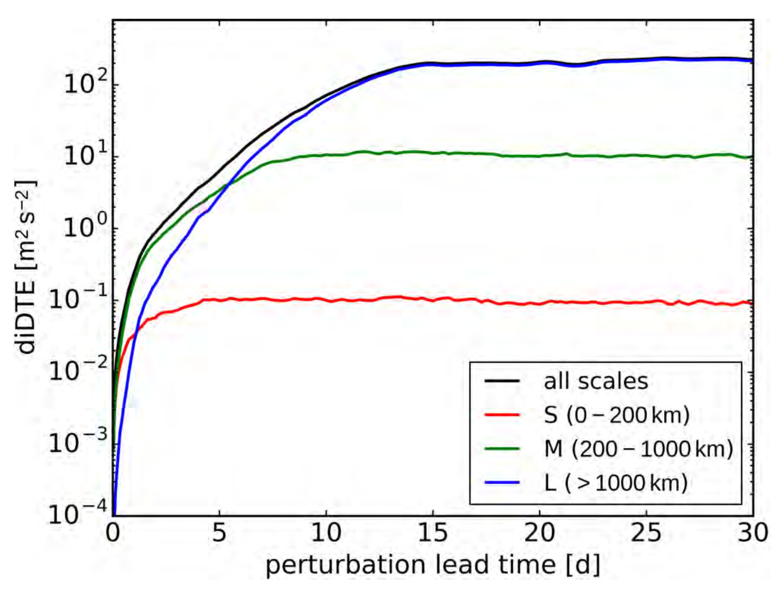
Rossby number (i.e. ratio of divergent over rotational component of difference wind) development with perturbation lead time for idealized simulations with different Coriolis parameters f. The plot clearly shows the dependence of the upscale error growth process on f.

Global simulations with stochastic convection

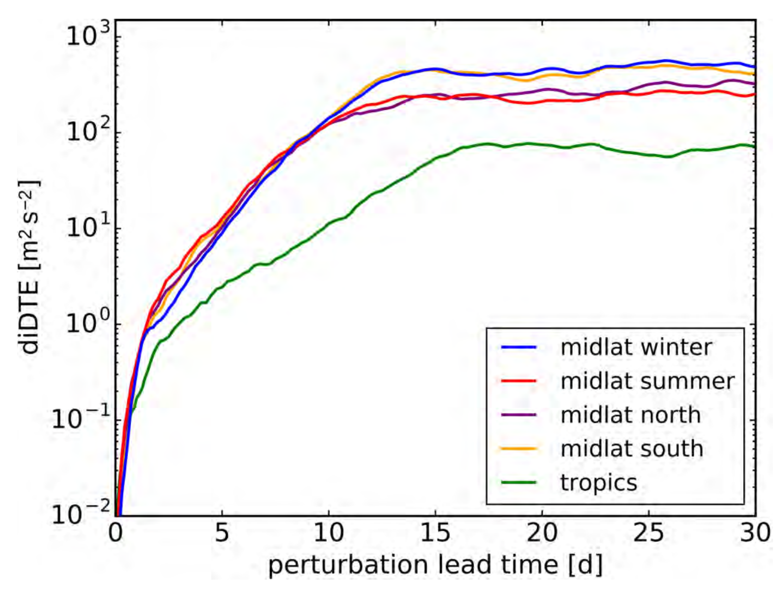
The global ICON model and the PC convection scheme were used to investigate upscale error growth from convection to planetary saturation.



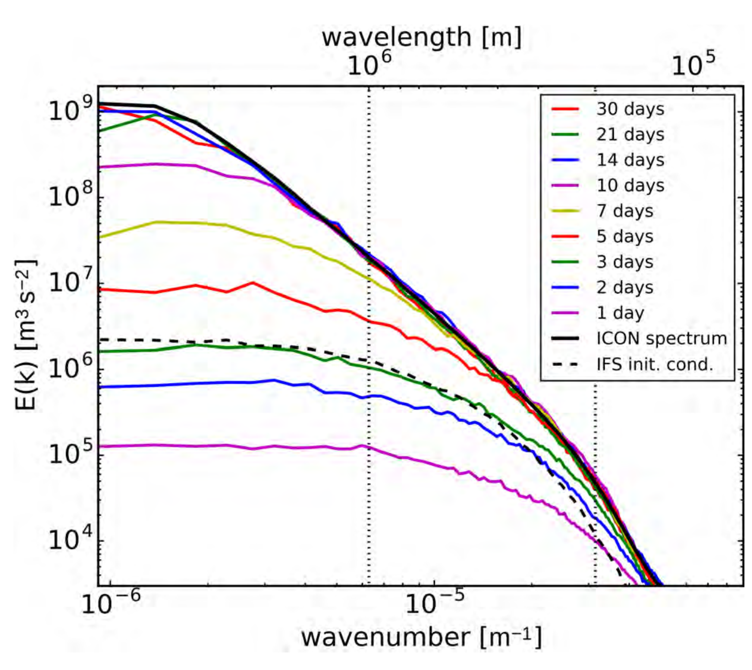
Jet structure at 300 hPa of the two simulations with different realizations of the convection. Each colored contour shows a 1000 m²/s² geopotential interval.



Domain-integrated difference total energy over perturbation lead time, separated by scale and averaged over both simulations.



Domain-integrated difference total energy over perturbation lead time, separated by region and averaged over both simulations.



Zonal kinetic energy spectrum of the difference wind in the mid-latitudes at several perturbation lead times, averaged over both simulations and both hemispheres. For reference the mean absolute spectrum and the mean spectrum of the differences in the IFS ensemble initial conditions are also shown.

These result suggests intrinsic predictability limits to be *in general*...

- predictability time of synoptic scales is limited to 7-10 days
- predictability time of planetary scales is limited to 14 days
- perfect initial conditions could increase predictability by 3 days