An alternative weather type classification based on spatio-temporal field derivations

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Classifications in atmospheric sciences and their applications
Present state & future directions
COST 733: Harmonisation and Application of weather type classification in Europe
Plan

• standard vs. alternative

• definition of spatio-temporal measures

• application to Alpine gridded time series

• results and conclusion
Field distribution/pattern

- e.g. pressure, geopotential, temperature
  \( \Psi(x,y) \)

Flow direction/speed

- e.g. pressure-, geopotential-gradient
  (1st directional derivative)
  \( \Delta \Psi/\Delta x; \Delta \Psi/\Delta y \)
Vorticity (curvature/shear) of the flow field second spatial derivative
e. g. Laplace of the field (stream function) \( \nabla^2 \Psi \)

Two-/multilevel approach
Two-/multivariate approach
e. g. 3D field information
e. g. pressure + humidity
Major problem:

Selection of adequate time window; validity

24h – 12h – 6h ?

Alternative:

Additional consideration of temporal derivatives, as most weather events are connected to transient systems
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Selection of adequate spatiotemporal scale: → Hovmoller diagram (spatio-temporal coherency)


and of tropical cloud systems (right), from Wallace and Hobbs, 1977
Selection of adequate spatiotemporal scale:

→ Hovmoller diagram (spatio-temporal coherency)

e. g. to correlate (synoptic/frontal) precipitation events with pressure fields:

$$\Delta t \sim 3h, \Delta l \sim 100km \ (c \sim 10 \ m/s)$$

to avoid influence of meteorological noise and to allow an application of global scale (climate) models:

$$\Delta t \sim 24h, \Delta l \sim 500km$$
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Domain of MESOCLIM pressure grid points around Austria
Red and green dots represent the E/W and N/S extent of ∆l
Color points are precipitation stations within certain climatic regions
E/W pressure gradient (green) and 24 hr precipitation (blue) in July/August 2003
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Application to (heavy) precipitation

Median and quartiles of 24 hr precipitation with regard to classes of second mixed derivatives $\Delta^2 p/(\Delta x \Delta t)$ for summer season (April – September) 1971 – 2005 for climate region VIENNA
Same as before but for $\Delta^2 p / (\Delta y \Delta t)$ and climate region NORTH
Scatter plot of 24 hr precipitation with regard to the second mixed derivatives of msl pressure for summer 2003; E/W (horizontal axis) and N/S (vertical axis)
Distribution of the second mixed derivative (top) and the traditional weather pattern Classification of all cases with precipitation above 20mm/24h in summer seasons of 1971 – 2002 for climate region NORTH
E/W pressure gradient (green) and 24 hr precipitation (blue) in July/August 2003
Median and quartiles of 24 rh precipitation with regard to classes of second mixed derivatives $\Delta^2 p / (\Delta y \Delta t)$ for winter season (October – March) 1971 – 2005 for climate region NORTH
Application to climate change
(Project „Trendanalyse von hydrometeorologischen Extremwerten“)
KliEn: Klima- und Energiefonds

Relative frequencies of extreme values of second mixed derivatives \( \Delta^2 p / (\Delta y \Delta t) \)
Derived from 35 years of MESOCLIM, ERA40 and climate models (ECHAM5 and HADCM3)
Relative frequencies of extreme low values of the 15 day variance of the second mixed derivatives $\Delta^2 p / (\Delta y \Delta t)$ derived from 35 years of MESOCLIM, ERA40 and climate models (ECHAM5 and HADCM3)
Conclusion:

The spatio-temporal weather pattern classification represents a more dynamical approach and seems to work nicely with precipitation/drought events in mid latitude mountainous terrain.

In contrast to traditional discrete weather pattern classifications it represents a continuous measure for the atmospheric state. Hence it allows an indication of intensity.

The combination of the mixed derivatives and flow direction seems to be a promising extension. It will be tested towards other weather phenomena and other regions in Europe and other parts of the world.
Thank you for your attention