INITIATION OF AIRMASS DEEP MOIST CONVECTION

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INTRO

- University Vienna, Institute of Meteorology
- EU project HERA / MAP
- Satellite department @ ZAMG – SATMANU
- Forecaster since 2004

Late activities:
- Weather type classification (COST733, KLI_EN)
- Trusted Spotter Network Austria (ZAMG, Skywarn, ESSL / ESWD, meteopics.eu)
OUTLINE

- Forecasting: case study & task
- Limitations of forecaster regarding initiation of airmass / pulse DMC
- Integrating upper level dynamics / moisture gradients / MSG WV
- Concept of symmetric instabilities
- Derivation of a geostrophic wind-vector-gradient matrix
- RGB testing
INITIATION OF AIRMASS DMC

FORECAST CASE STUDY: SYNOPTIC BACKGROUND, 28 July 2005

CONVECTION WEEK 2011
THOMAS KRENNERT

MSLP (VIOLET), H500 (CYAN)
INITIATION OF AIRMASS DMC

FORECAST CASE STUDY: SYNOPTIC BACKGROUND

THETAe surface (red), 850 hPa (yellow)
CONVECTIVE INITIATION
FORECAST CASE STUDY: MSG HRVIS LOOP
@ 1130 UTC: where exactly will DMC occur?

Transition from shallow convection towards DMC?

Ingredients based methodology: Instability – moisture – lift

Clear and proven concept

Local variability of moisture supply, entrainment, CIN

Sufficient quantities of ingredients to resolve CIN / inversions?

About 20 - 30% seasonal convective activity of this type / Alpine region
FORECAST CASE STUDY: OPERATIONALLY AVAILABLE PRODUCTS

- MSG / Nowcasting
  - 3.9μ / 6.2μ / 7.3μ - RGB
  - Severe Storm RGB
  - Air Mass RGB
  - Clout Top Height
  - Microphysics / day
  - Global / Regional Instability Index
  - Multisensor Precipitation + NWCSAF precipitation products
  - NWCSAF products i.e. RTD
- RADAR (no signal so far), TEMP
- NWP – models: DMO + post processing
  - Low – res, local, high – res non hydrostatic, hybrids: artefacts?
- High resolution analysis and nowcasting:
INITIATION OF AIRMMASS DMC

FORECAST CASE STUDY: NOWCASTING, INCA ANALYSIS

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ZAMG

28-07-2005
10 UTC
INITIATION OF AIRMASS DMC

NOWCASTING, ALADIN – SURFACE MOCON FORECAST 1200 UTC
INITIATION OF AIRMASS DMC
FORECAST CASE STUDY: RASO VIENNA 1200 UTC

11035 28.07.05 12 UTC Wien

- Red: Unstable
- Yellow: Conditionally unstable
- Blue: Stable
- Green: Inversion

Pressure

Level of Free Convection (LFC)
Height: 8400 ft GND, 737 hPa
INITIATION OF AIRMASS DMC

FORECAST CASE STUDY: MSG HRVIS LOOP - CONTINUED
Theta-e gradient slightly indicated, dry intrusion, conditional instability increasing, CAPE increasing?
Zero line shear indicates vertical wind speed gradient (min+max)

SANTURETTE, P., GEORGIEV, C. G., 2005; MARTIN, et al., 1999
Isopleths 1,5 PVU at respective pressure level – „dry intrusion“
INDICATIONS FOR SYMMETRIC INSTABILITY

- ECMWF 0.5 parameter: Equivalent potential Vorticity (layer 850 – 500 hPa)
- Mostly negative (dashed lines)
- Leading to consideration of the concept of Symmetric instabilities
### COMPARISON OF INSTABILITIES

<table>
<thead>
<tr>
<th>Gravitational</th>
<th>Symmetric</th>
<th>Inertial</th>
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<tbody>
<tr>
<td><strong>Dry</strong></td>
<td>Absolute instability</td>
<td>Symmetric instability</td>
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<td>[\frac{d\bar{\theta}}{dz} &lt; 0]</td>
<td>[\frac{d\bar{\theta}}{dz} &lt; 0; \quad \frac{dM_g}{dx} \bigg</td>
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<td>[-\frac{dT}{dz} &gt; \Gamma_d]</td>
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<tr>
<td><strong>Conditional</strong></td>
<td>Conditional instability (CI)</td>
<td>Conditional symmetric instability (CSI)</td>
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<tr>
<td><strong>Potential</strong></td>
<td>Potential instability (PI)</td>
<td>Potential symmetric instability (PSI)</td>
</tr>
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<tr>
<td><strong>Inertial</strong></td>
<td>[M_g-\bar{\theta}_e^s\ \text{relationship}]</td>
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Schultz and Schumacher (1999)
COMET: Slantwise convection
Schultz and Schumacher (1999):
- Convection can possess characteristics of slantwise convection, gravitational convection, or both
- Coexistence of: CSI/PSI, CI/PI, adequate moisture / lift
- Release of convective–symmetric instability results in a mixture of moist slantwise convection and moist gravitational - the latter prevails
- CI / PI is a special case of CSI / PSI in which $\theta$es / $\theta$ surfaces not only tilt more steeply than Mg surfaces, but are overturned

- Mg – $\theta$ relationship for dry symmetric instability is equivalent to geostrophic potential vorticity PVg

Limitations:
- Identifying regions with PVg / MPVg might also indicate PI / CI and gravitational convection
Xu (1986a): “upscale development,“:
- Initial development of small-scale moist gravitational convection
- Release of symmetric instability -> mesoscale banded convective clouds
- Most likely occurrence: outside of frontal regions, absence of synoptic-scale air mass boundaries.

Jascourt et al. (1988):
- Scattered cumulus cloud bands simultaneously grew into lines of thunderstorms
- Along the 700–500-mb shear, layer with weak moist symmetric stability
- Conditionally unstable to gravitational convection (CAPE > 1000 J kg⁻¹)
- Nature and organization of convection can be modulated by the symmetric stability
Distinct vertical shear / little directional shear

Weak gravitational stability

MPVg becoming smaller or negative by deformation at the boundary zone

Strong thermal gradient induced by the dry and cold intrusion along with the WV dark zone

Saturated buoyant air parcel reaches a zone of distinct negative MPVg

Release of SI -> slantwise convection might follow (cms⁻¹), sufficient?
The calculation of $Mg - \theta$ relationship (Dixon, 2000):
- Cartesian coordinates necessary
- Not easily used in operational forecasting

The calculation of SCAPE
- Also no frequent use in operational forecasting

The calculation of $MPVg < 0$ / increase or decrease of its gradient

“Horizontal gradients of conservative field quantities (such as: $P$, $Pe$, $\Theta e$) are strengthened by the geostrophic wind field when deformation terms are dominant” (Bluestein 1993, Houze 1993, Emanuel 1994)

-> Derivation of a geostrophic wind-vector-gradient matrix (“NUE”)
divergence

\[ D = \frac{\mu u_g}{\mu x} + \frac{\mu v_g}{\mu y} \]

stretching deformation

\[ E = \frac{\mu u_g}{\mu x} - \frac{\mu v_g}{\mu y} \]

shearing deformation

\[ F = \frac{\mu v_g}{\mu x} + \frac{\mu u_g}{\mu y} \]

relative vorticity

\[ \chi = \frac{\mu v_g}{\mu x} - \frac{\mu u_g}{\mu y} \]

\[ \mathbf{i} = \frac{D}{2} \cdot \left[ \frac{(E^2 + F^2 - x^2)}{4} \right]^{\frac{1}{2}} \]

Only the negative values of the NUE – parameter indicate strengthening of the MPV – gradient.

In order to avoid imaginary results the parameter is calculated

\[ \dot{i} = \text{sign}(x) \frac{\bar{Q} D}{2} + \left[ \frac{(E^2 + F^2 - X^2)}{4} \right]^{\frac{1}{2}} \]

In combination with the WV gradients a zone for favourable DMC onset can be highlighted (easily applied operationally)
INITIATION OF AIRMASS DMC

PROPERTIES OF NUE: CASE STUDY
INITIATION OF AIRMASS DMC
ALADIN MPVg (850-500hPa), NUE 850 / 700 / 500 hPa, 0600UTC
INITIATION OF AIRMASS DMC

ALADIN MPVg (850-500hPa), NUE 850 / 700 / 500 hPa, 1200UTC
INITIATION OF AIRMASS DMC
RGB: IR 8.7µ / WV 7.3µ / WV 6.2µ
INITIATION OF AIRMASS DMC

RGB: IR 8.7μ / WV 7.3μ / WV 6.2μ
INITIATION OF AIRMASS DMC

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RGB: IR 8.7µ / WV 7.3µ / WV 6.2µ
INITIATION OF AIRMASS DMC

RGB: IR 8.7µ / WV 7.3µ / WV 6.2µ   LOOP
References


DIXON, R. S., 2000: Diagnostic studies of symmetric instability. Ph.D. dissertation, University of Reading, 128 pp. [Available from Department of Meteorology, University of Reading, Earley Gate, P.O. Box 243, Reading RG6 6BB, United Kingdom.]


