Atmospheric forcing of the Eastern Mediterranean Transient by midlatitude cyclones

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The Eastern Mediterranean Transient (EMT)

  

- Hydrological changes in Eastern Med enhanced density of Aegean – increased salinity due to reduced freshwater input and circulation changes – preconditioned for deep convection.
  

  
Datasets

• OAFlux latent and sensible heat fluxes
  – Merged satellite and reanalysis product, 1°, daily resolution

• ECMWF Interim Reanalysis (ERA Interim) 10m meridional winds and 2m air temperatures
  – ~ 0.7°, 6-hourly resolution

• NASA’s Modeling, Analysis, and Prediction (MAP) Climatology of Mid-latitude Storminess (MCMS) cyclone centers and tracks
  – Derived from 1.5°, 6-hourly resolution ERA Interim sea level pressure

Anomalous Turbulent Heat Fluxes from the Aegean during the EMT

NDJF 1991/1992

NDJF 1992/1993

Net flux highly correlated on synoptic time scales with wind, air temperature and air humidity

<table>
<thead>
<tr>
<th>Net Flux</th>
<th>Wind</th>
<th>Air Temp</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.89</td>
<td>-0.85</td>
<td>-0.79</td>
<td></td>
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</tbody>
</table>
Heat Advection over the Aegean by the Meridional Wind (vdT/dy)

In NH winter, dT/dy < 0

North wind: \( v < 0; \) \( v dT/dy > 0; \)

South wind: \( v > 0; \) \( v dT/dy < 0; \)

warm advection
Decomposition of $\text{vdT/dy}$

$$A = [\overline{A}] + [A'] + \overline{A}^* + A^{*'}$$

$[\ ] = \text{zonal mean}$

$^* = \text{deviation from zonal mean (eddy)}$

$\_ = \text{temporal mean (stationary)}$

$' = \text{deviation from temporal mean (transient)}$

$A$ comprises:

$\overline{A}$, the time mean zonal mean, e.g., latitudinal temp gradient

$[A']$, the time varying zonal mean, e.g., subseasonal variation of the latitudinal temp gradient

$\overline{A}^*$, the time mean spatial eddies, e.g., standing waves

$A^{*'}$, the time varying spatial eddies, e.g., storms
Decomposition of $\text{vdT/}dy$

$$A = [A] + [A'] + \overline{A}^* + A^{*'}$$

- Substitute $v$ and $dT/\text{dy}$ for $A$, multiply
- Select largest terms

**storms**

- $v^{*'}[dT/\text{dy}]$: Advection of mean temperature gradient by transient eddy meridional winds (storms)
- $v^{*'}dT/\text{dy}^*$: Advection of stationary eddy temperature gradient by transient eddy meridional winds
- $v^{*'}dT/\text{dy}^{*'}$: Advection of transient eddy temperature gradient by transient eddy meridional winds

**stationary features**

- $\bar{v}[dT/\text{dy}]$: Advection of mean temperature gradient by stationary eddy meridional winds
- $\bar{v}dT/\text{dy}^*$: Advection of stationary eddy temperature gradient by stationary eddy meridional winds
Aegean Sea Turbulent Fluxes and Heat Advection

- day-to-day flux variability controlled by advection of mean temperature field by storms, especially during 1991/1992 and 1992/1993 winters

Heat advection by storms strongly correlated with turbulent flux, especially during the enhanced EMT winters (0.9 vs. 0.7)

Interannual variability of $\frac{\partial T}{\partial y}$ controlled by stationary eddy winds (correlation = 0.97)
Cyclone Frequency Anomalies during EMT

- Dipole pattern in both years – fewer storms in central Mediterranean compared to eastern Mediterranean
- Produces reduced warm advection (fewer central Med storms) and enhanced cold advection (more eastern Med storms) over Aegean Sea
Storm-related anomalous heat advection

vdT/\,dy anomaly when there is a storm in the Central Mediterranean (defined as 10-15E, 38-40N and 15-20E, 30-40N), NDJF 1989/1990 – 2008/2009


- Fewer central Med storms lead to reduced warm advection over Aegean
- More eastern Med storms lead to enhanced cold advection over Aegean
- Both enhance turbulent heat loss from Aegean
Conclusions

• Atmospheric forcing during most intense portion of EMT was due to altered cyclone activity
• Reduced frequency of central Med storms led to fewer warm advection events
• Increased frequency of eastern Med storms led to more cold advection events

Further Questions

• Relationship with large scale oscillations?
  • No correlation between Aegean flux and NAO, in agreement with Josey, 2003
  • Relationship with NCP/EAWR pattern – correlation of 0.60 between monthly mean NCP and Aegean turbulent fluxes
• Will there be more frequent EMT-like cyclone patterns in the future?
  • Poleward storm track shift could lead to fewer central Med storms
  • Higher resolution climate models/nested modeling techniques may be able to help
Thank you!


For more information on the NASA Modeling, Analysis, and Prediction Program Climatology of Mid-latitude Storminess dataset, please contact George Tselioudis or Michael Bauer at NASA GISS.