

Thermodynamic forces leading to production of a record hailstone in Vivian, South Dakota, USA

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SOUTH
DAKOTA

NORTH DAKOTA

MONTANA

SOUTH DAKOTA

MINNESOTA

MOUNT
RUSHMORE

VIVIAN
HAILSTONE

SIOUX
FALLS

WYOMING



IOWA

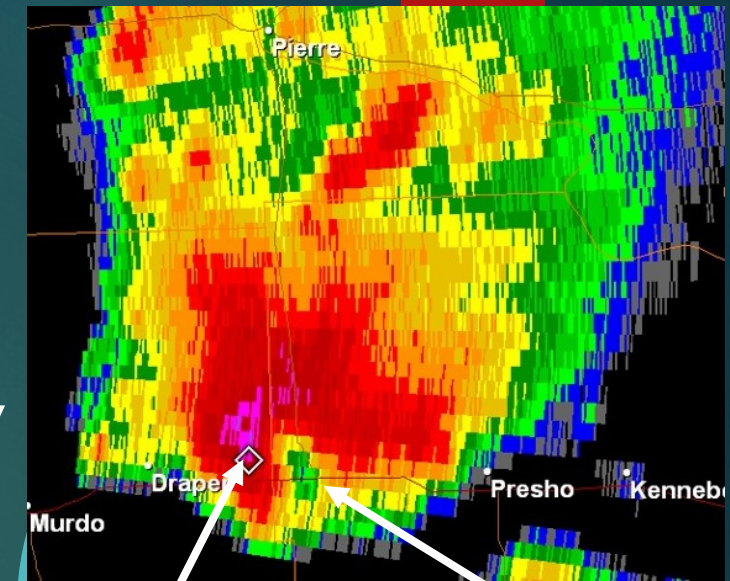
600
KM

NEBRASKA

On 23 July 2010
we expected a
tornado – our
colleague
chased the storm



Doppler
radar
reflectivity

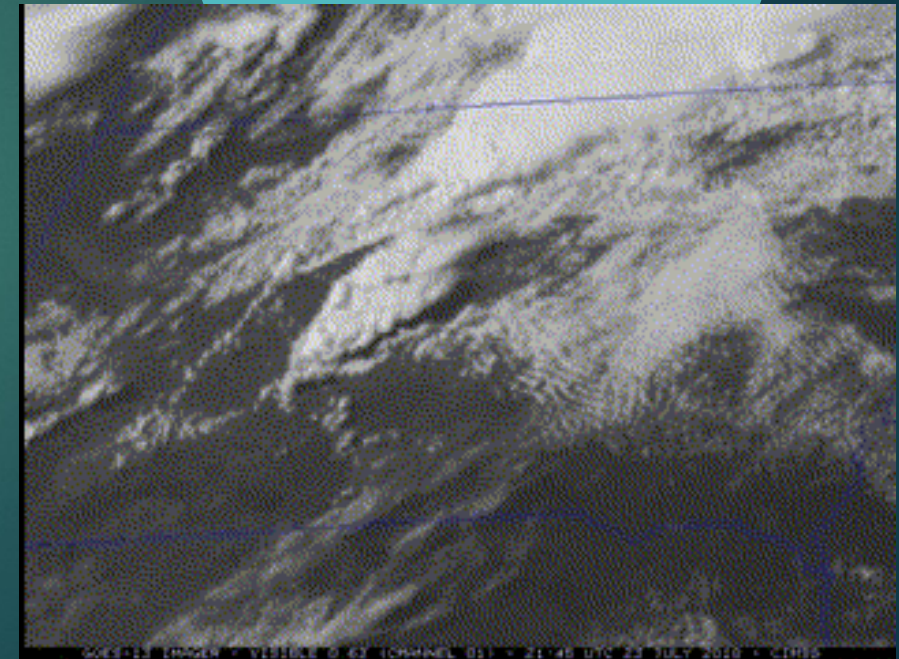


Hail core

Updraft



5 PM News









Vivian Hailstone

0.879 kilogram

HEAVIEST HAILSTONE
RECORDED IN THE WESTERN
HEMISPHERE (WMO)

0.203 m Диаметрър

0.473 m обиколка



Dr. Charles Knight Hail Expert

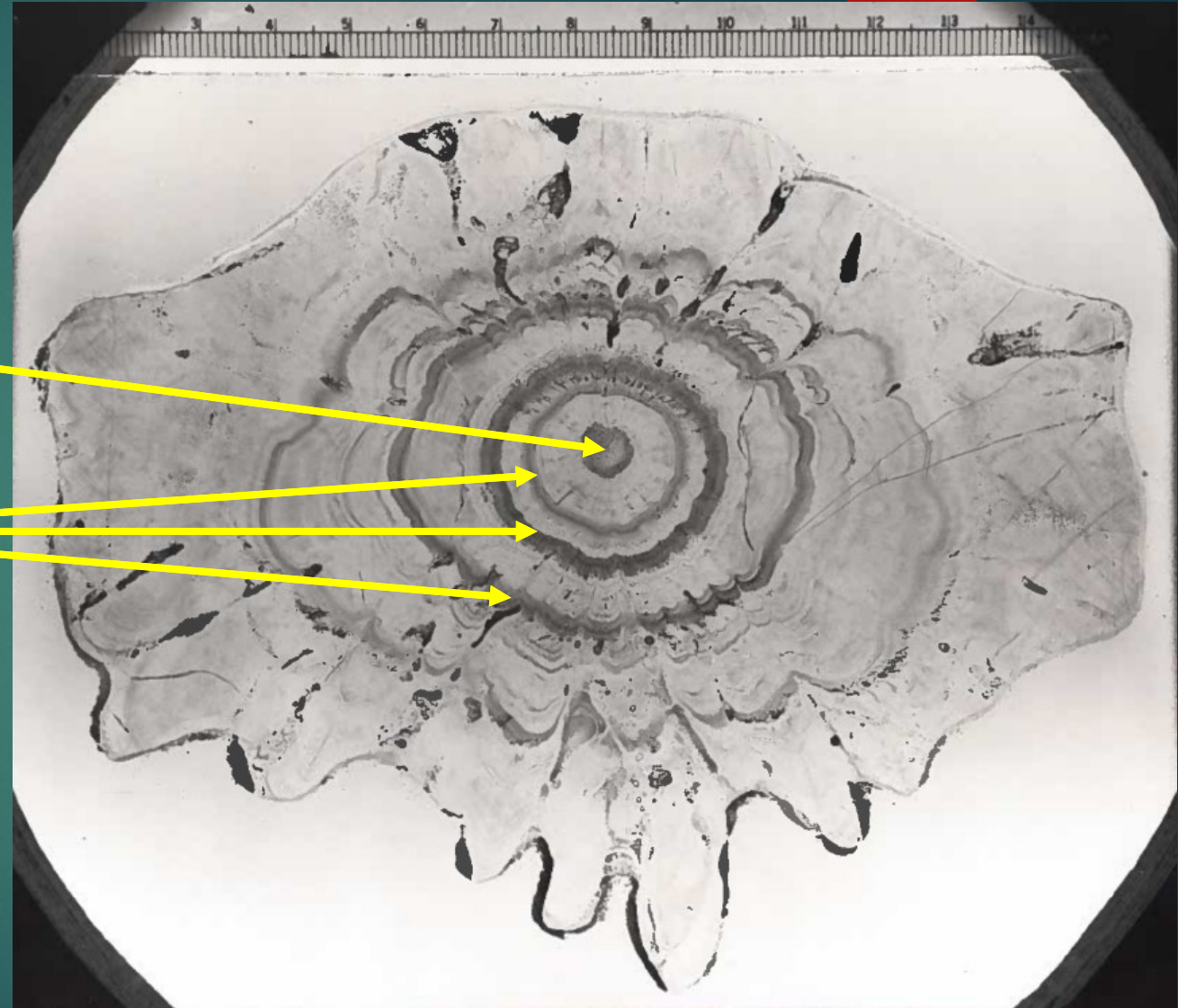
CASTS OF THE HAILSTONE
MADE AT THE NATIONAL
CENTER FOR ATMOSPHERIC
RESEARCH

BOULDER, COLORADO USA

Giant hailstone cross section

Embryo

Growth layering:
Changes in contrast –
the rings – contain air
bubbles from changes
in the growth
conditions



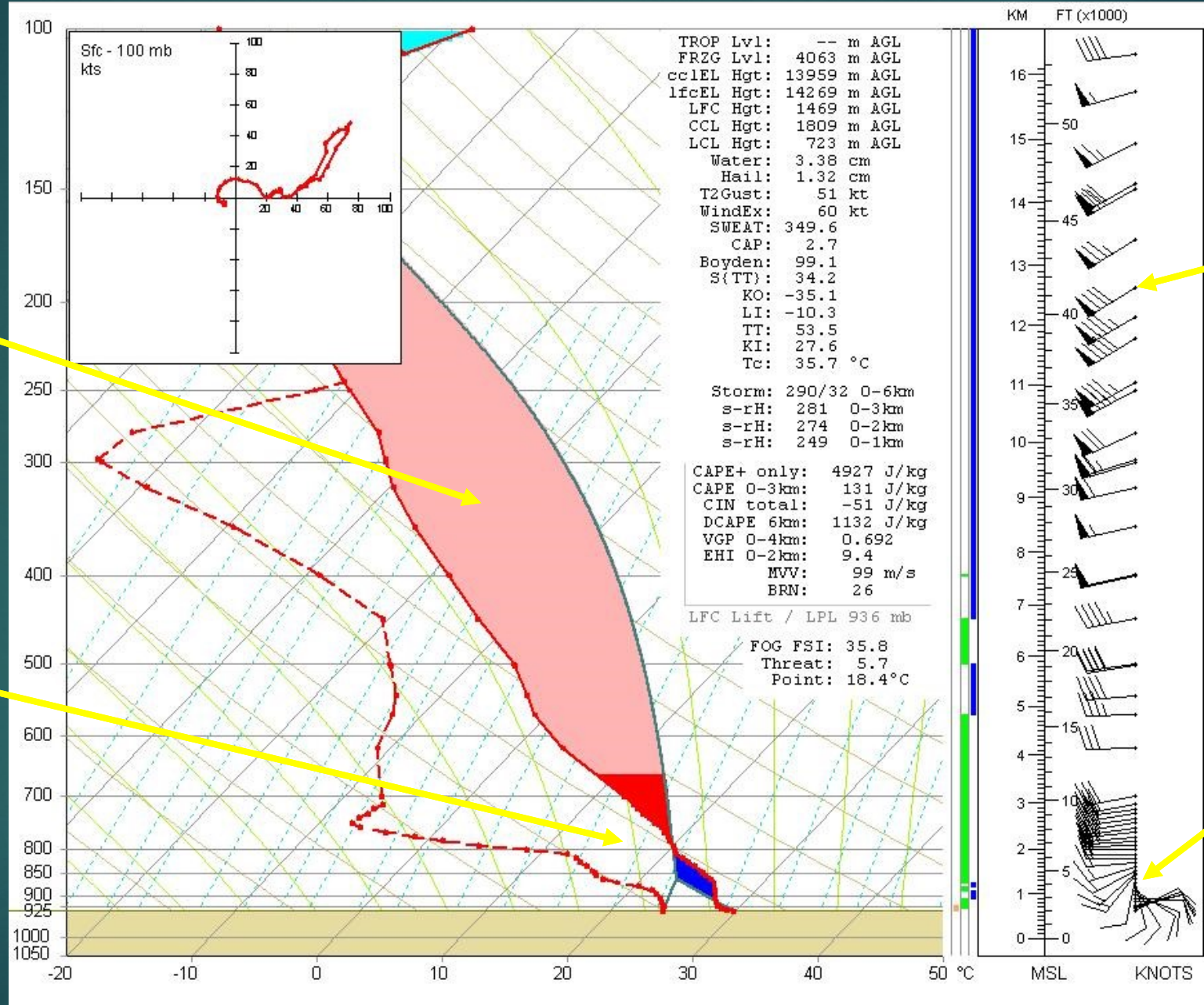
Cloud top -70°C

Surface 30°C



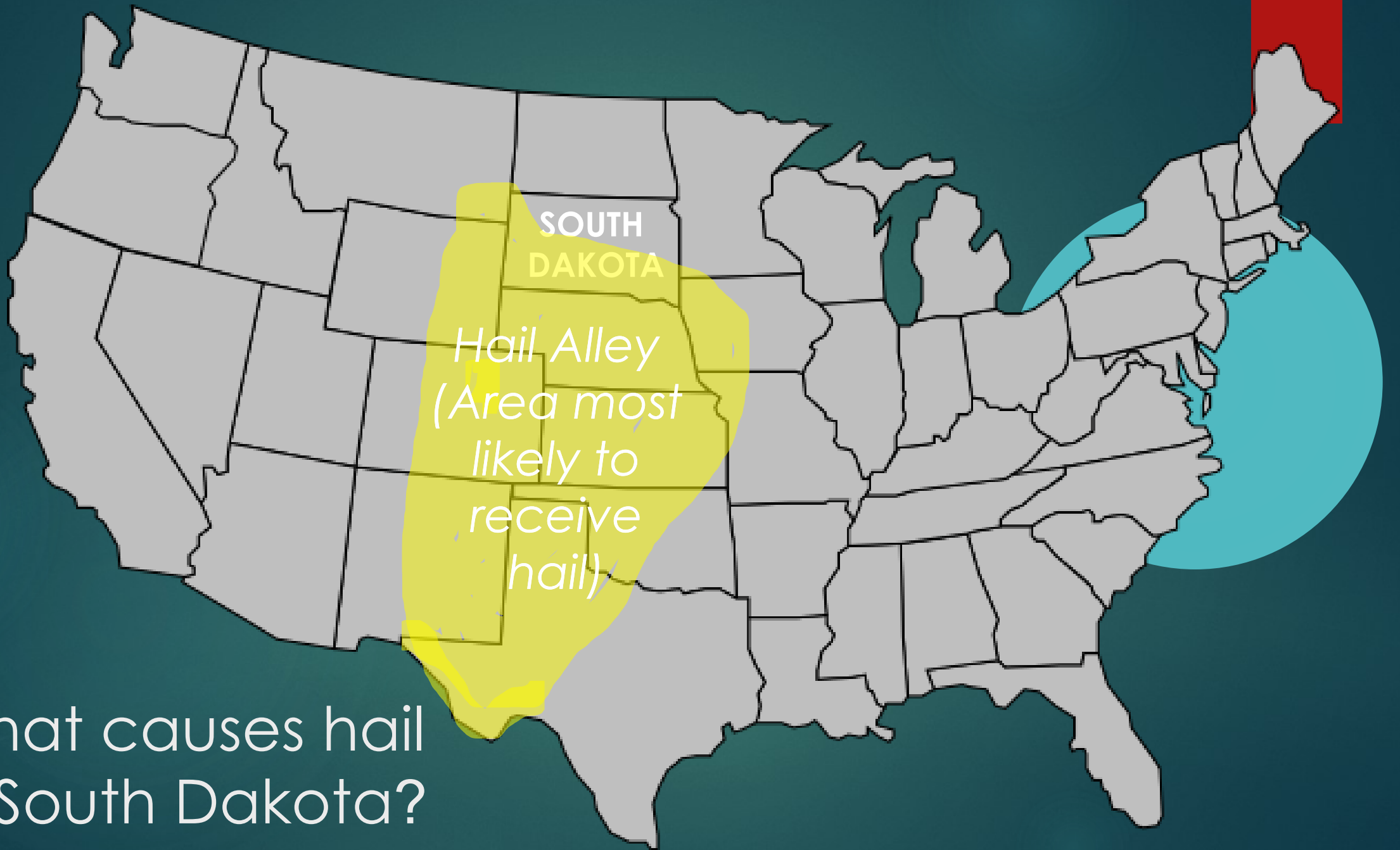
“Fat”
SBCAPE:
4927 j/kg

“Low” Lifted
Condensation
Level
(LCL 723 m)
and
Level of Free
Convection
(LFC 1469 m)



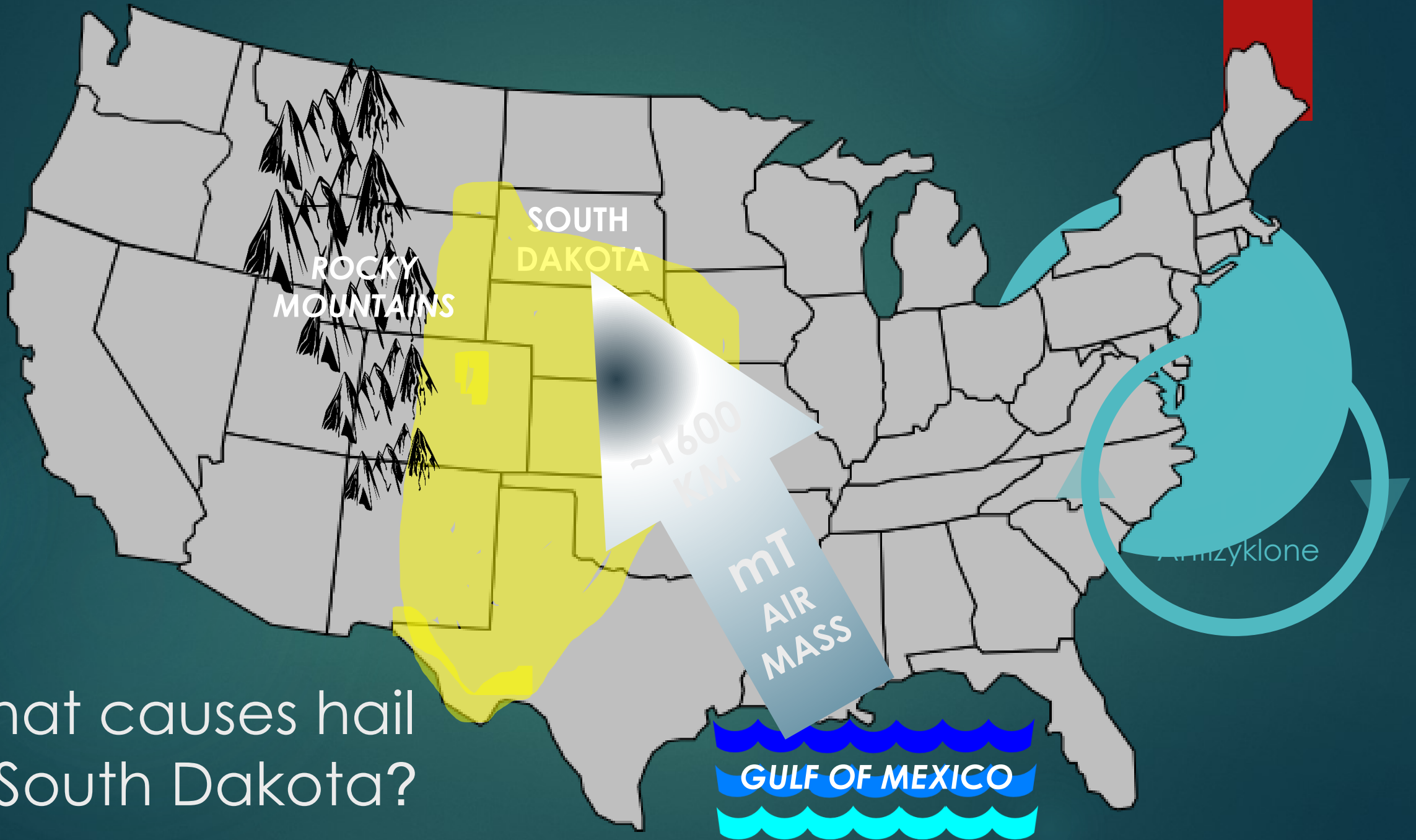
Jet
streak

Directional
wind
shear



What causes hail
in South Dakota?

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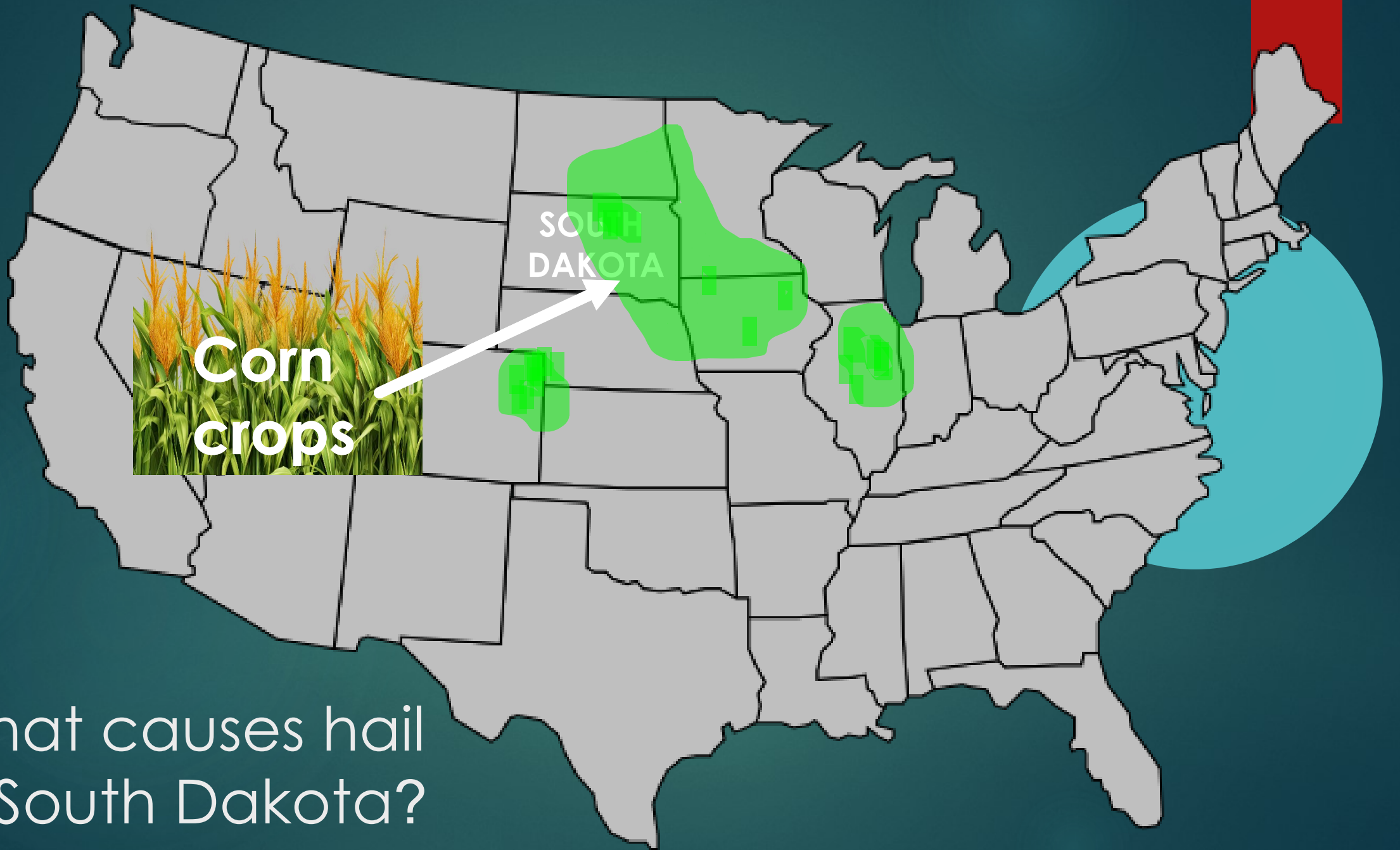
Updraft Vertical Velocity (UVV):

$$\sqrt{2 \times \text{CAPE}} = \sim 99 \text{ m/s}$$

(minus buoyancy lost to entrainment of surrounding air)

Falling hailstone velocity: > 44 m/s

CAPE	4285	700	1000
CINS	82	40	20
HELCTY	489	150	250
EHI	13.09	0.5	1
BRN	23.67	50	45
NCAPE	0.37	0.1	0.2
LI	-8	1	-3
TT	54	48	53
TQ	20	12	17
K Indx	35	30	40
Shw1tr	-7	-1	-4
SWEAT	589	250	350
EqLv	43,869	25000	32000
WBZ	10,519	10000	9000
LFC	5,875	8000	4000
LCL	2,085	4000	2000
PW	1.67	1	1.5



What causes hail
in South Dakota?



- **EVAPORATION AND TRANSPIRATION RATES OF CORN CROPS CAN AVERAGE 97% OF POTENTIAL EVAPOTRANSPIRATION (PET)**
- **ACTUAL EVAPOTRANSPIRATION IS APPROXIMATELY 3.3 MILLIMETERS PER DAY (INCREASING DEW POINTS)**
- **EVAPOTRANSPIRATION RATES USUALLY PEAK IN LATE JULY INTO AUGUST**

Cheresnick and Basara, BAMS May 2005

Forecast models have difficulty assimilating this moisture



Evapotranspiration from corn crops likely provided additional Convective Available Potential Energy (CAPE) to the environment that produced the record Vivian, South Dakota hailstone

