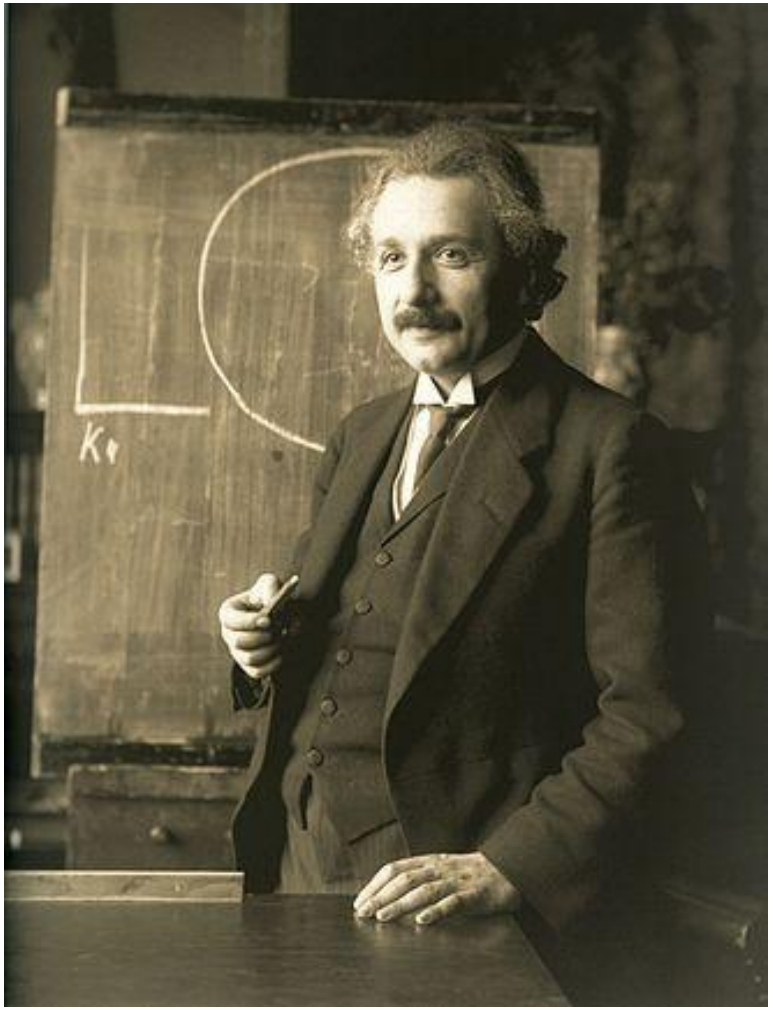
What has Einstein ever done for meteorology?



SCIENTIFIC EVENTS

THE ESTABLISHMENT OF AN INTERNATIONAL BUREAU OF METEOROLOGY[1]

AT the sixth session of the International Committee on Intellectual Cooperation, held at Geneva from July 27 to July 29, 1925, the chairman communicated to the committee a proposal submitted by M. van Everdingen, director of the Netherlands Meteorological Observatory and chairman of the International Meteorological Committee (I. M. C.), with regard to the creation of an International Bureau of Meteorology (I. B. M.) (Annex 4 to document C. 445, M. 165, 1925).

After a brief discussion, the committee requested the undersigned to consider, together with M. van Everdingen and several other experts, how the committee might assist in establishing this bureau.

The present report sets out our conclusions:

M. van Everdingen's proposal was defined in a letter which General Delcambre, director of the French Meteorological Service and chairman of a special committee set up by the International Meteorological Committee, addressed officially to the International Institute for Intellectual Cooperation on November 23, 1925.

The [illegible] Committee is composed [illegible]

[illegible] operation [illegible] with [illegible] *ple* to cooperate with the [illegible] Committee for the creation of an International Bureau of Meteorology in accordance with the suggestions set out above. It might authorize the present subcommittee to act on its behalf as soon as the International Meteorological Committee has formally approved the scheme drawn up by the experts, so that the recommendations in question may be submitted to the Council of the League at its December session.

As regards the question of premises, a decision might be taken by the Committee of Directors of the Institute.

The representative of the International Commission for Air Navigation has promised to see that, at the next (October) meeting of the committee, that organization takes action on the same lines to secure the creation of the International Bureau of Meteorology.

(*Signed*) M. CURIE
H. A. LORENTZ
A. EINSTEIN

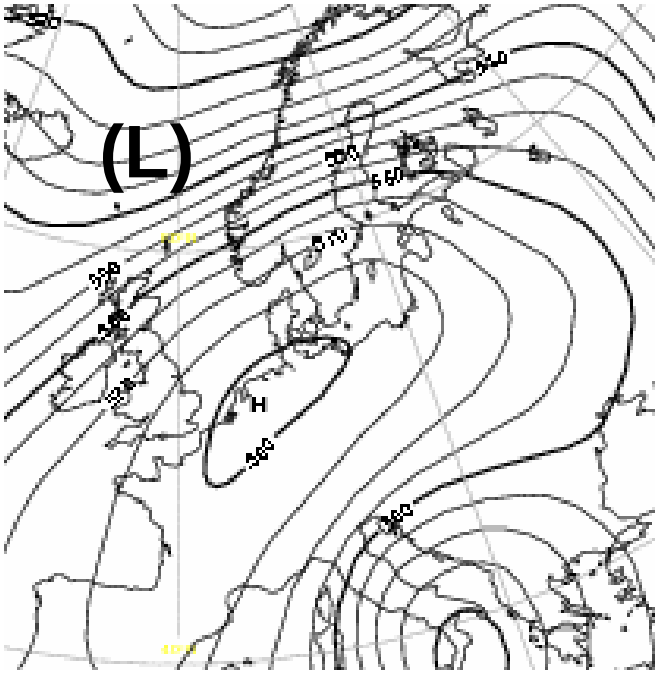
SCIENCE April 1927

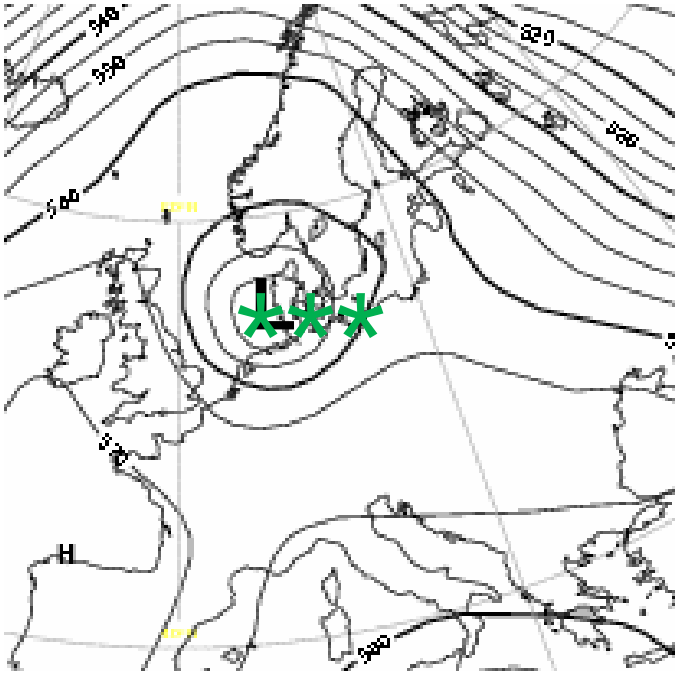
A personal teenage memory: The Winter Olympics in Innsbruck, Austria 1964

But in early January 1964 there had come no or very little snow!

. . . but then something happened.

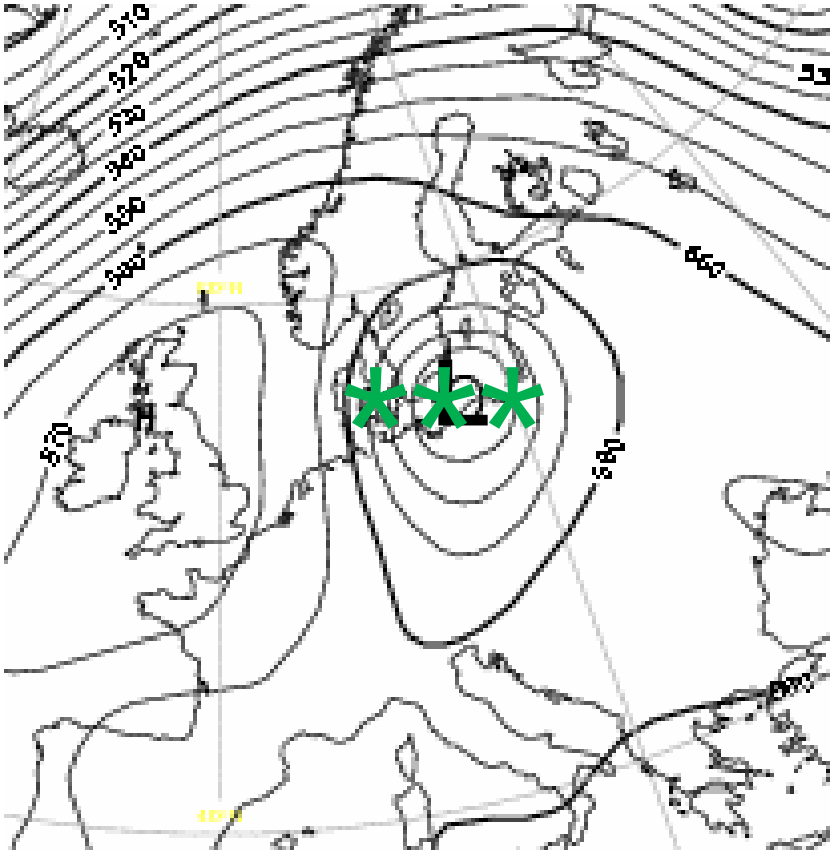
500 hPa over Europe on 4 and 6 January 1964.

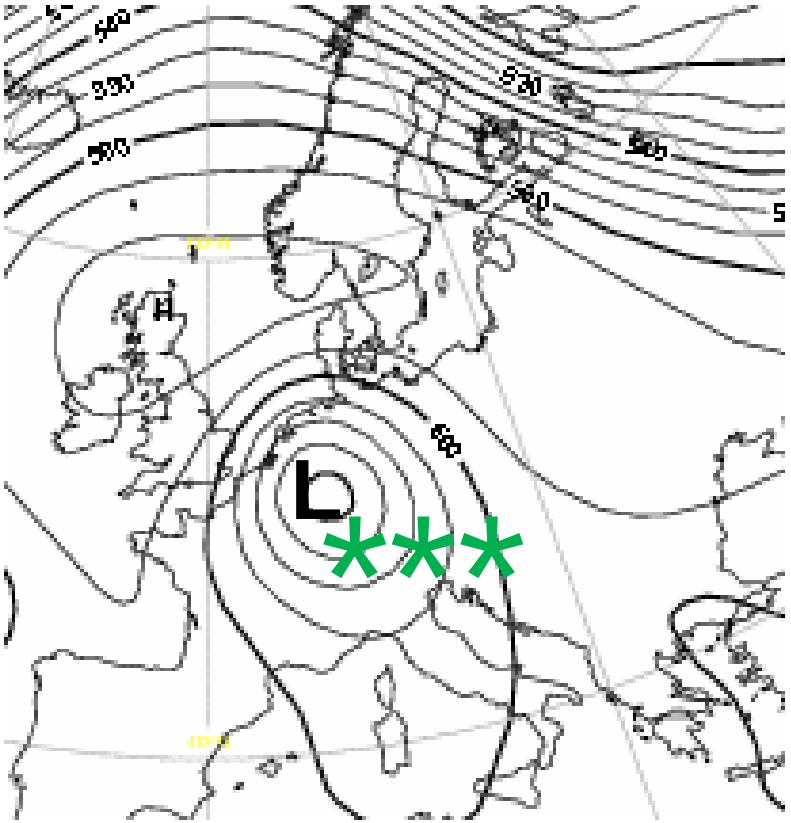




A “cut-off” with snow is formed over Scandinavia

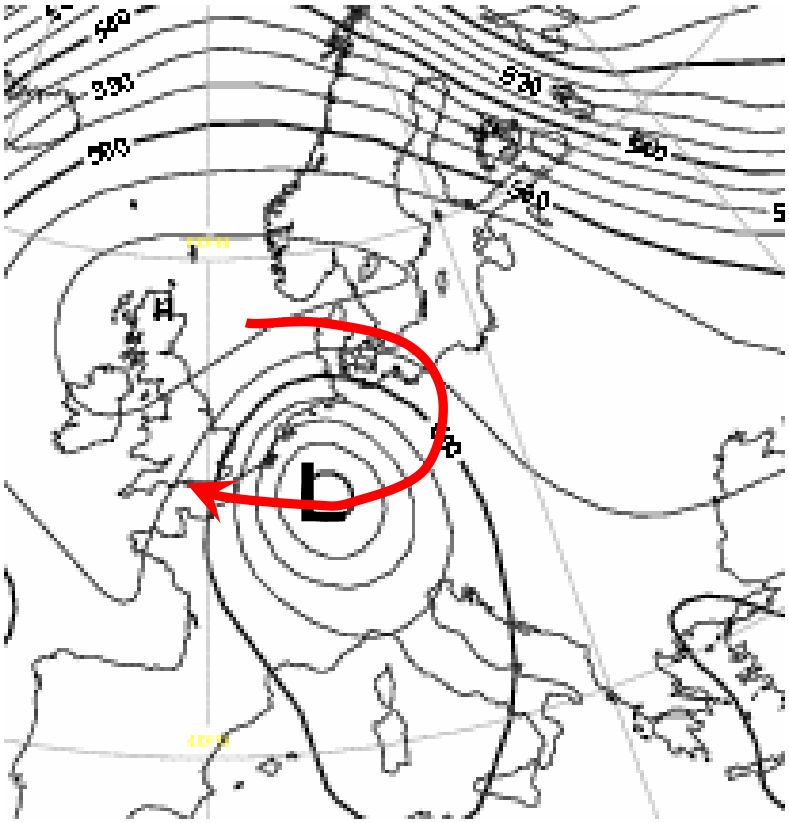
500 hPa over Europe 8 and 10 January 1964.





Snow comes to Innsbruck, not enough perhaps . . .

-But how could this vortex survive for so long 6-13 January 1964 over a cold surface?



In 1970 I was told by someone at Stockholm University that it was **“thanks to surface friction driving the winds out of the vortex”**

I didn’t dare to ask “how” since I got the feeling I ought to know!

Only 35 years later did I understand, partly thanks to Albert Einstein - and Annemarie Schrödinger, wife to Erwin Schrödinger

In autumn 1926 Einstein has tea with the Schrödinger family

Erwin and Annemarie Schrödinger 1920

Frau Schrödinger asked Albert Einstein why the tea leaves always gather at the center of the bottom of the tea cup?

Einstein explained how a centrifugal force acts on the rotating water. This force is proportional to the square of the velocity and thus, because of the friction, becomes weaker, in particular closest to the bottom of the cup.

This will result in a circular movement of the liquid which can be seen through the movement of the tea leaves

The story could have ended here hadn't Einstein found what he considered to be a wider application to his explanation, a mechanism that contributes to the meandering of rivers.

When water in a river flows through a bend it will follow a rotational motion. This "primary" motion will, just as in the tea cup, through friction towards the river banks, generate a "secondary" flow that will cause some erosion along the banks *on both sides*.

In the mid-1800's a Russian (Baltic-German) scientist **Karl Ernst Ritter von Baer** (1792-1876) during travels in Siberia had noticed that the big rivers tended to be eroded on their *right hand* side. He explained this to be due to the earth rotation ("Baer's Law").

Einstein takes up this idea

Nr. 420

Die Ursache der Mäanderbildung der Flussläufe und des sogenannten Baer'schen Gesetzes.

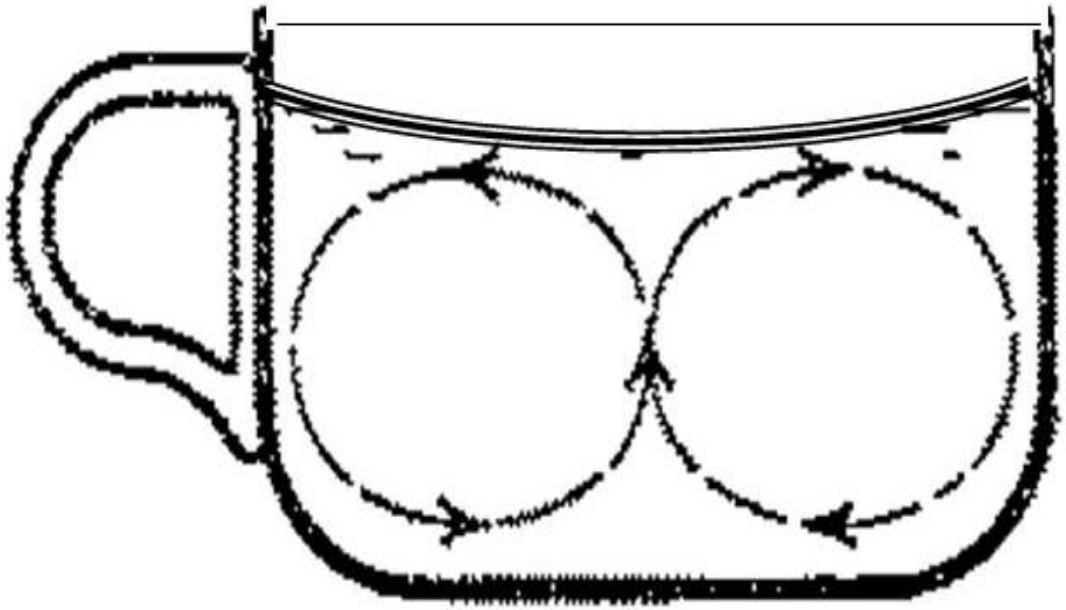
Von A. Einstein, Berlin.

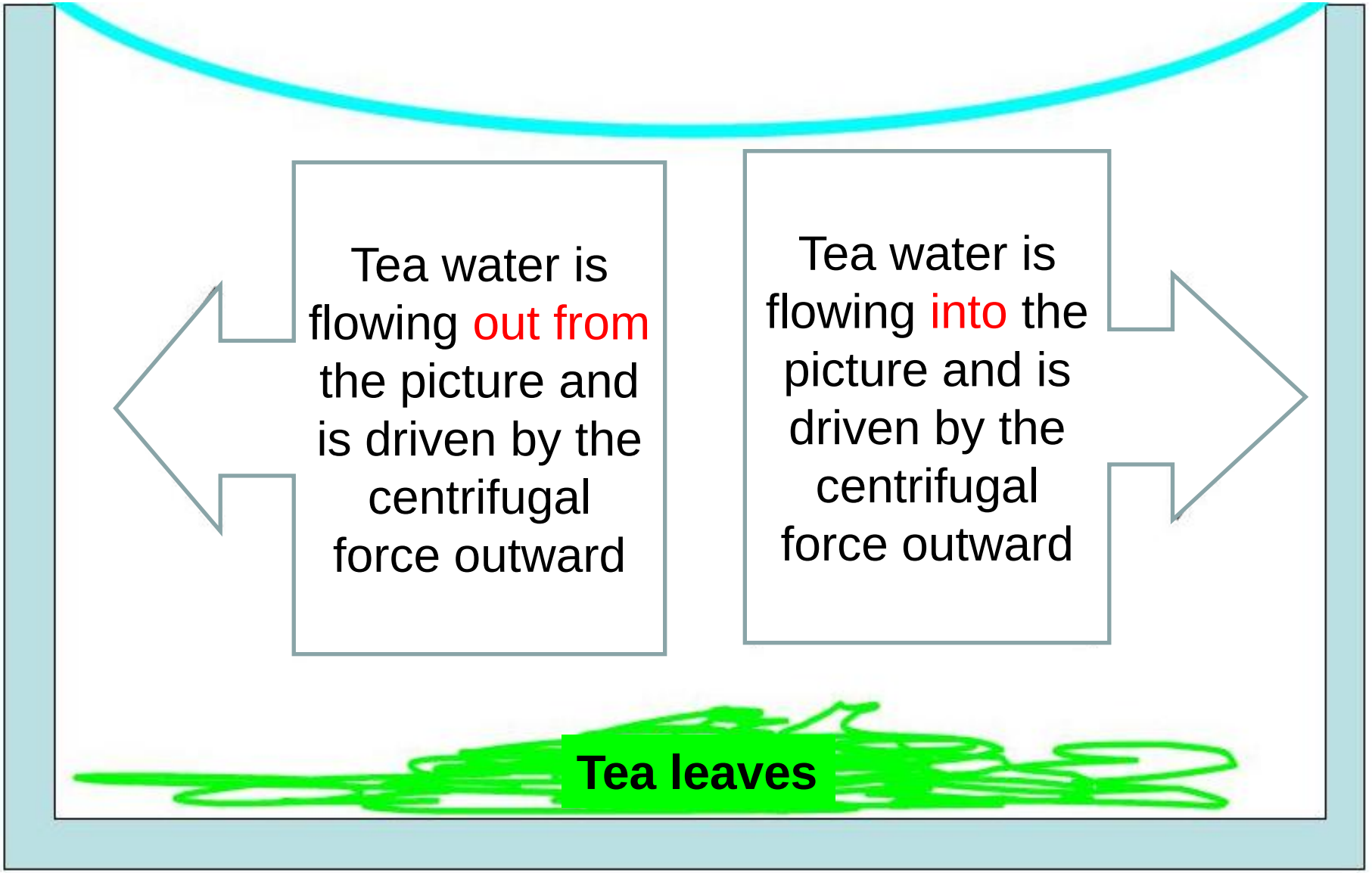
Es ist allgemein bekannt, dass Wasserläufe die Tendenz haben, sich in Schlangenlinien zu krümmen, statt der Richtung des grössten Gefälles des Geländes zu folgen. Ferner ist den Geographen wohlbekannt, dass die Flüsse der nördlichen Erdhälfte die Tendenz haben, vorwiegend auf der rechten Seite zu erodieren; Flüsse auf der Südhälfte verhalten sich umgekehrt (Baer'sches Gesetz). Ursache zur Erklärung dieser Erscheinungen liegen in grosser Zahl vor, und ich bin nicht sicher, ob dem Fachmann irgend etwas, was ich hierüber im Folgenden sage, neu ist, Teile der darzulegenden Überlegungen sind jedenfalls bekannt. Da ich jedoch niemand gefunden habe, der die in Betracht kommenden wesentlichen Zusammenhänge vollständig gekannt hätte, halte ich es doch für richtig, dieselben im Folgenden kurz — qualitativ darzulegen.

On 7 January 1926 Einstein had a presentation at the Prussian Academy on "**The cause of the formation of meanders in the courses of rivers and of the so-called Baer's law".** It was also publicized in the periodical "*Die Naturwissenschaften*" (The Natural Sciences) in March 1926 (Vol. 14, p. 223).

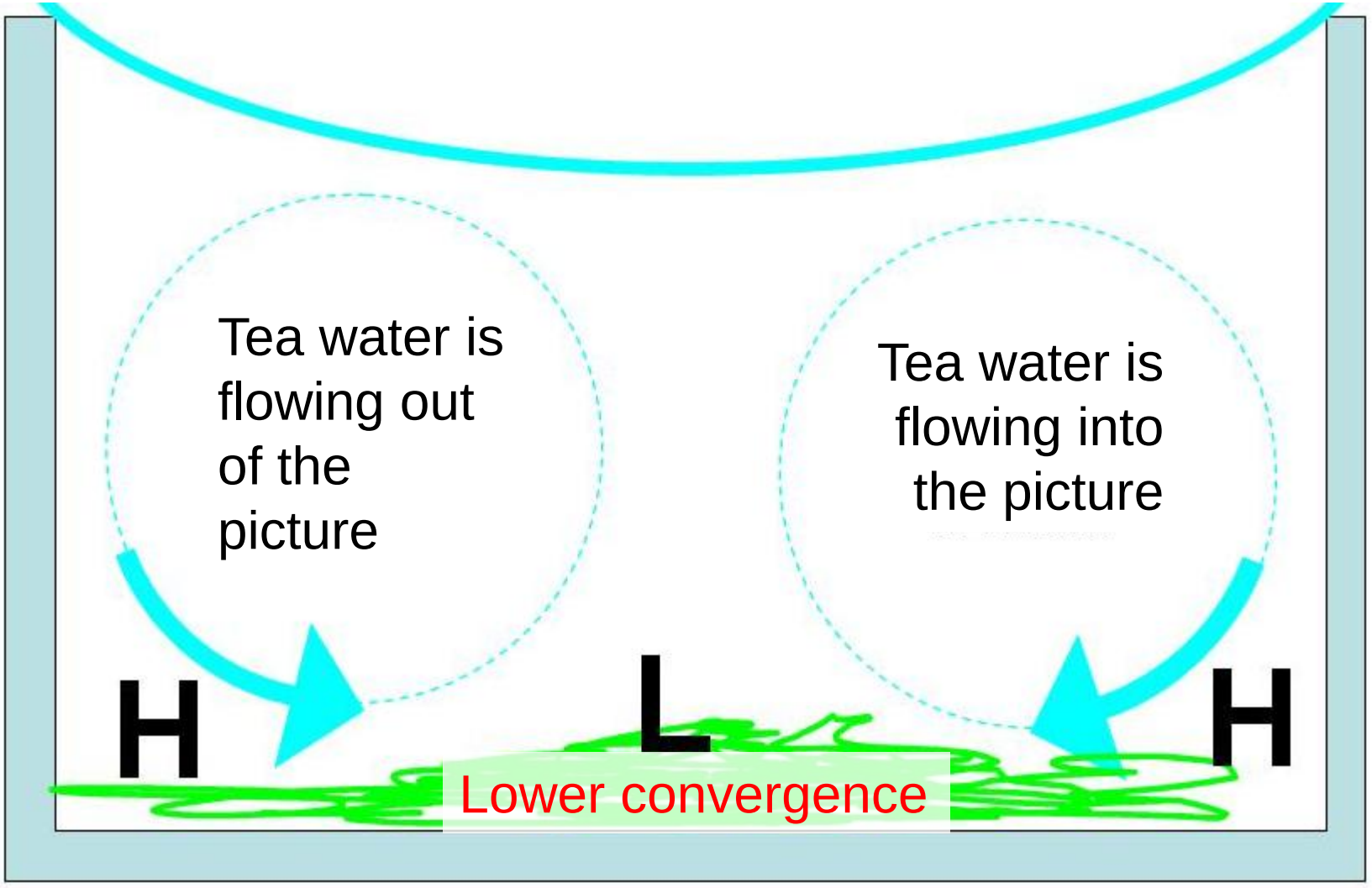
In Einstein's manuscript this tea cup image is crossed over. Perhaps Einstein or someone realised it was not quite correct – ***for a tea cup***

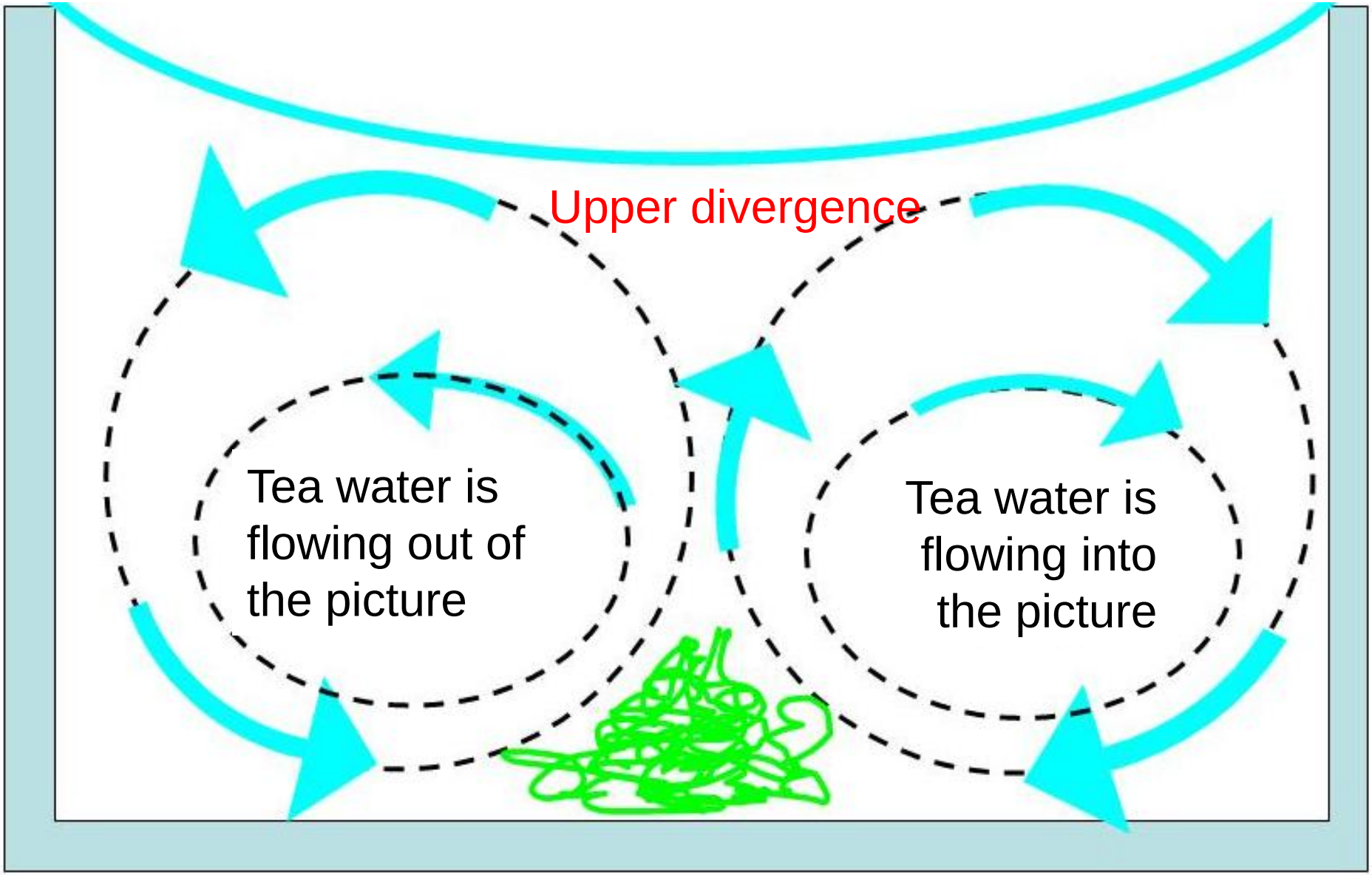
In a **tea cup**, the rotation and its centrifugal effect induces a parabolic upper surface

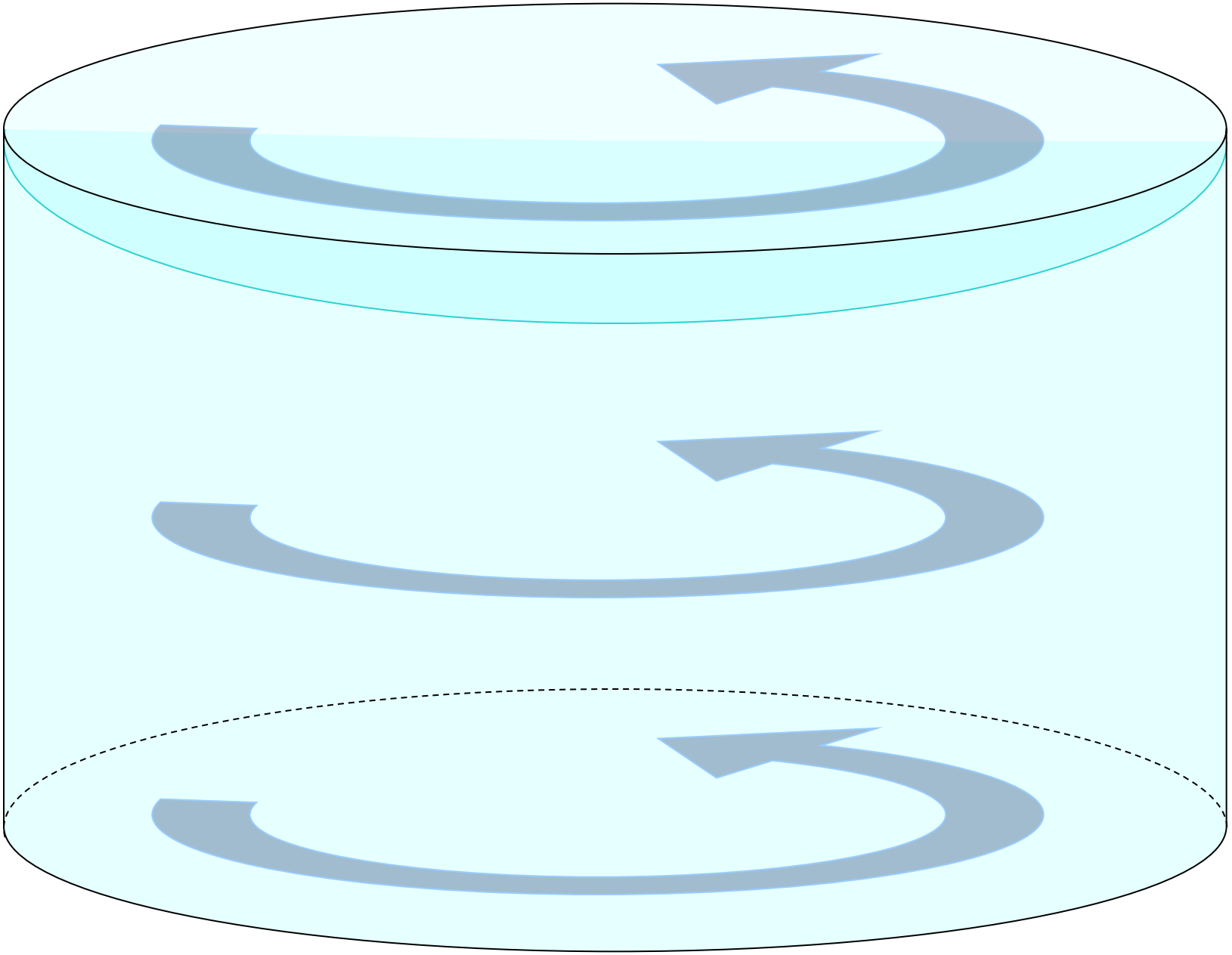



Tea water is flowing out from the picture and is driven by the centrifugal force outward
Tea water is flowing into the picture and is driven by the centrifugal force outward
Tea leaves

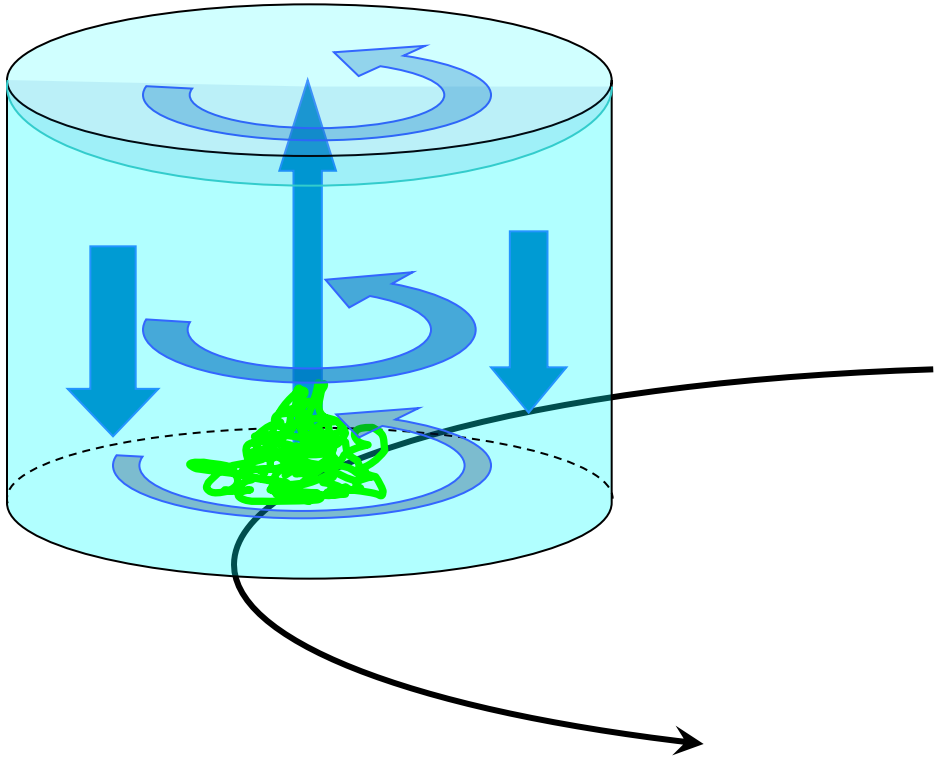
Higher water lower water higher water

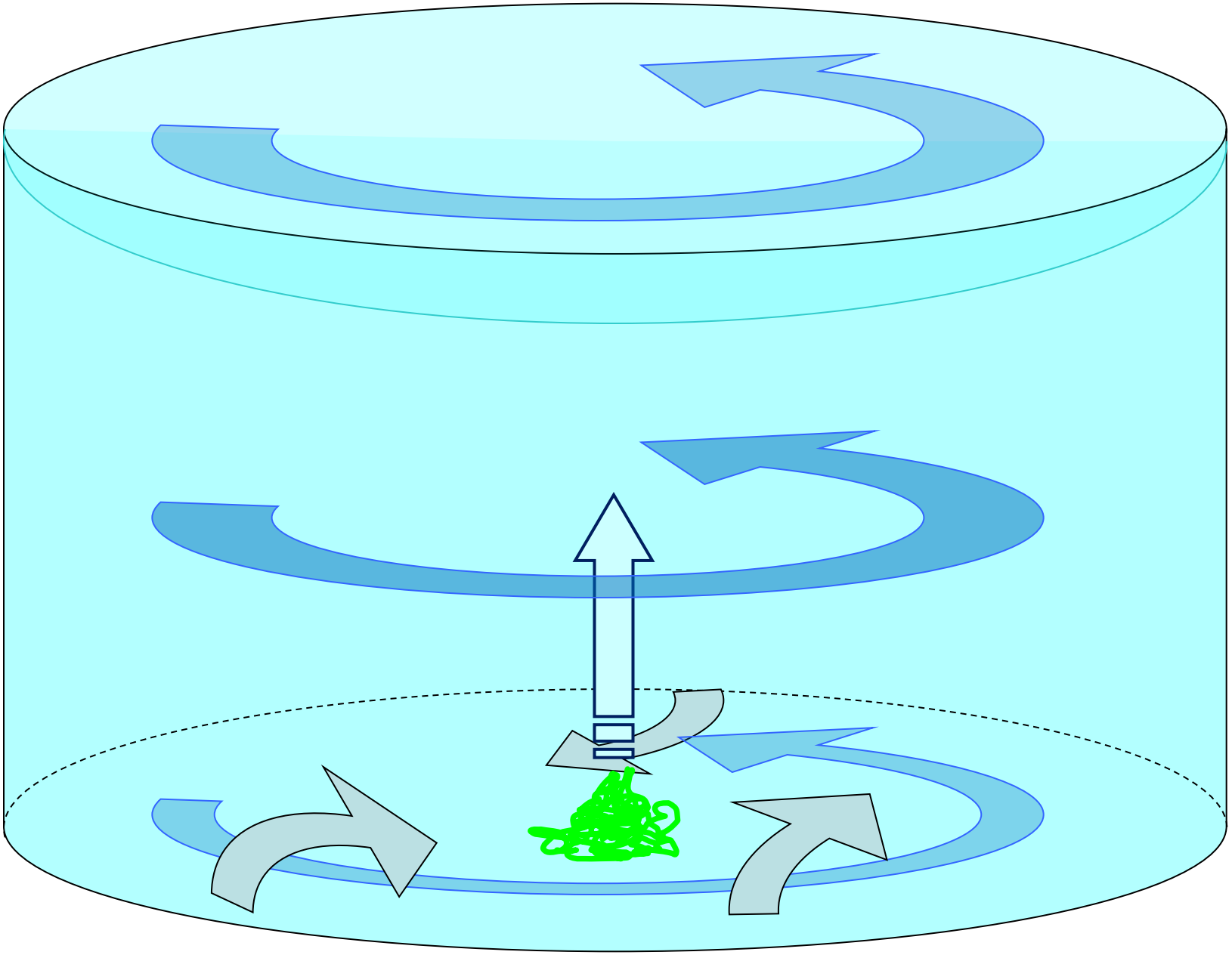



Upper divergence
Tea water is flowing out of the picture
Tea water is flowing into the picture

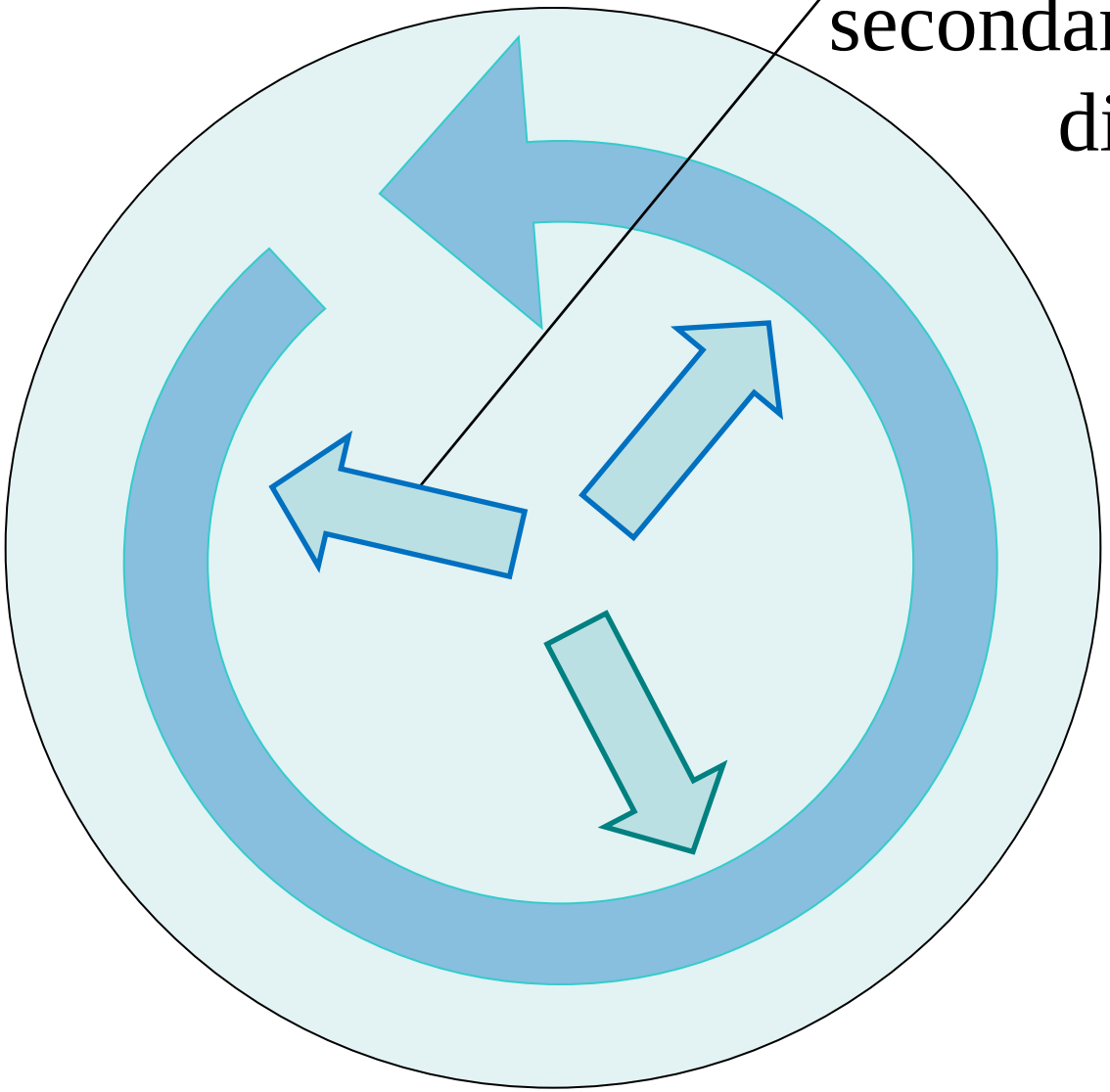


If the tea cup would be rotating as well
(as a cyclone is rotating with the earth)
the outflow would not be straight outward

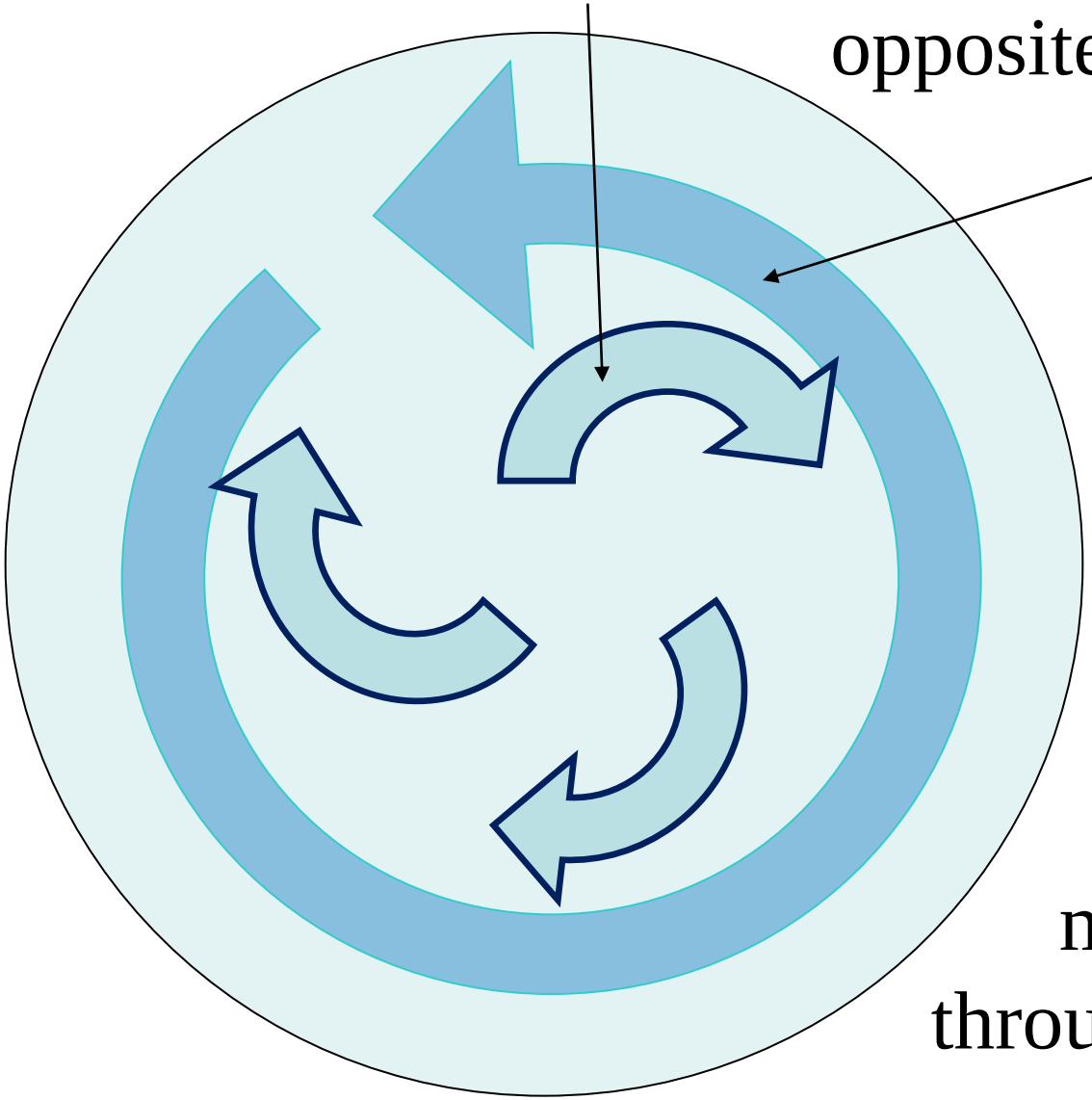




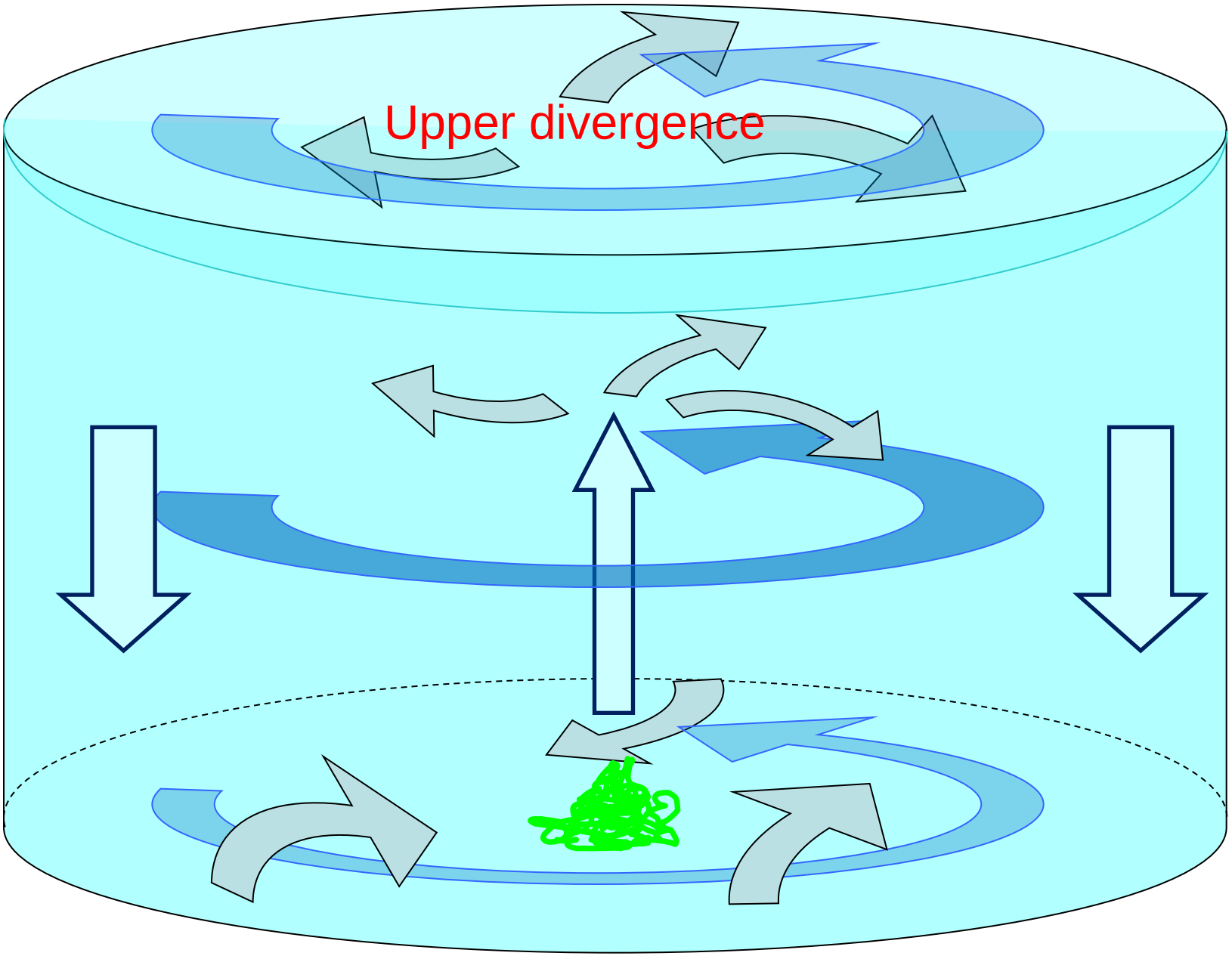
The outflow from the induced secondary circulation is directed outward



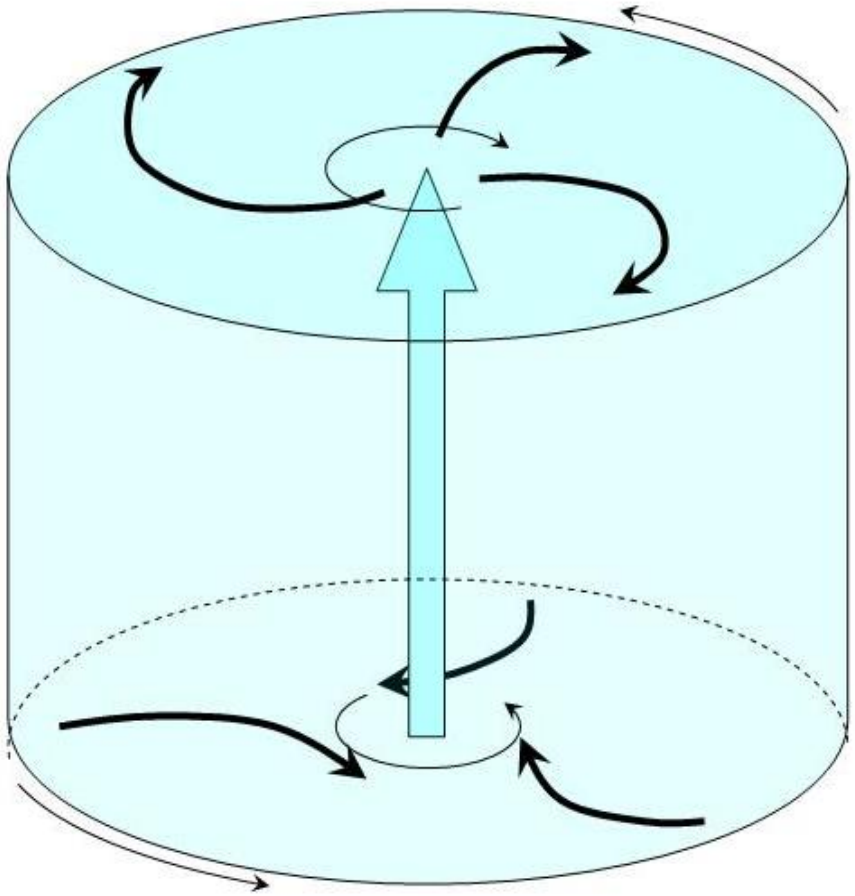
The induced secondary circulation is directed opposite to the primary



This “Ekman pumping” makes the breaking effect of friction much more efficient than through eddy diffusion

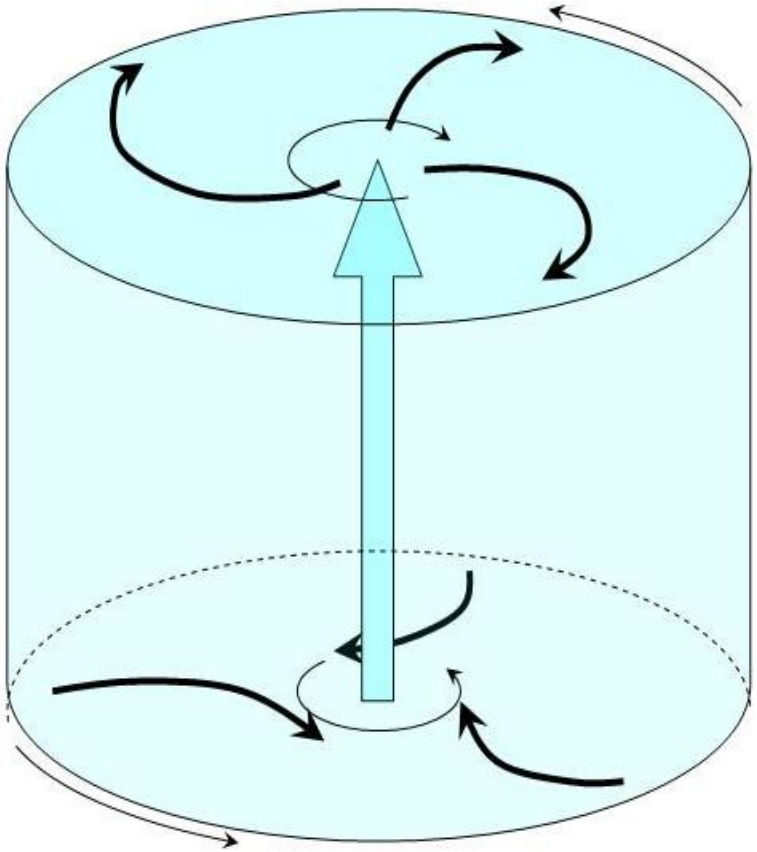

Upper divergence

A vortex is slowed down by inward surface friction inducing an upper secondary outward anticyclonic circulation **counter** to the cyclonic



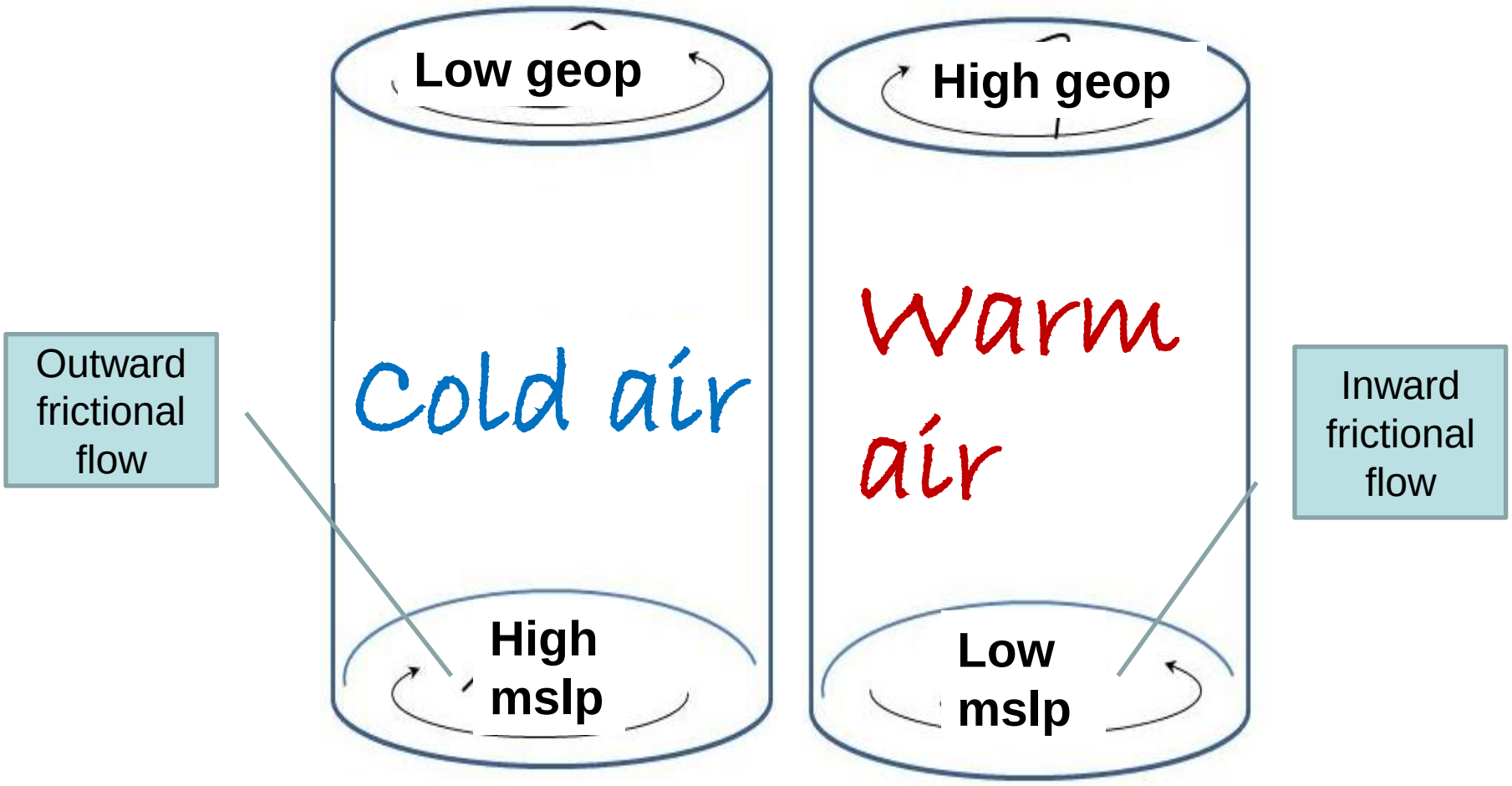
The friction at the surface is thereby efficiently spread vertical through the vortex and speeds up its slow down

So far there is no dependence on the temperature – the fluid is barotropic



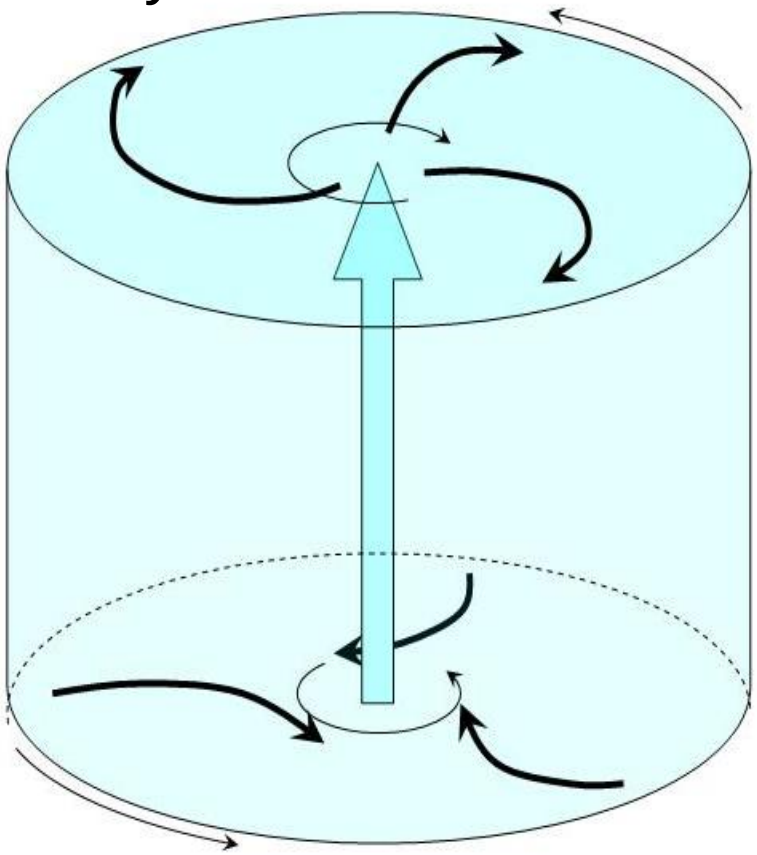
But in the real atmosphere with have air masses with different thermal properties

The relevance of the thermal air mass

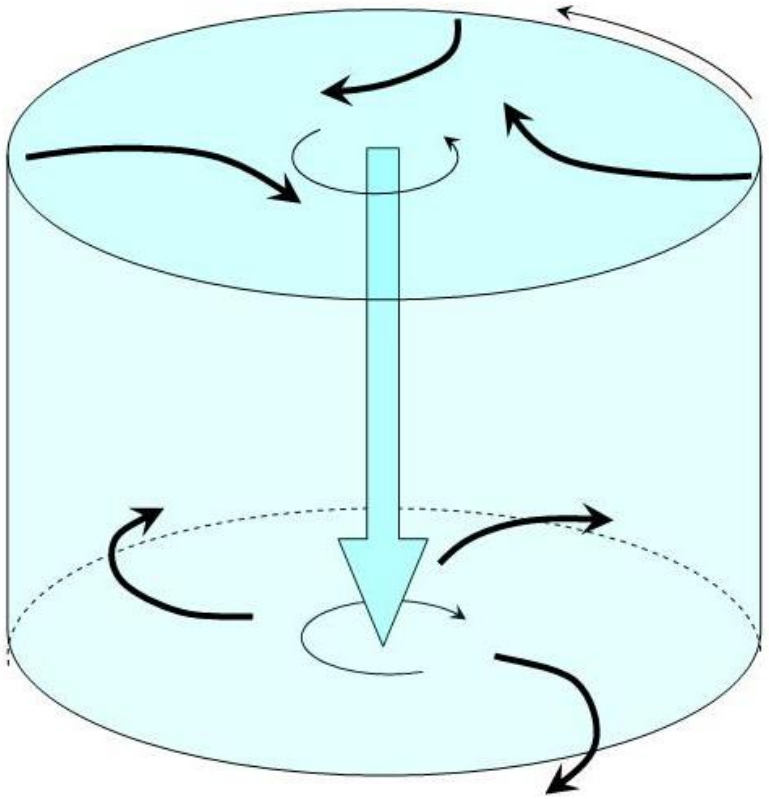


Mslp = mean sea level pressure **geop** = geopotential height

A vortex is slowed down by inward surface friction inducing an upper secondary outward anticyclonic circulation **counter** to the cyclonic

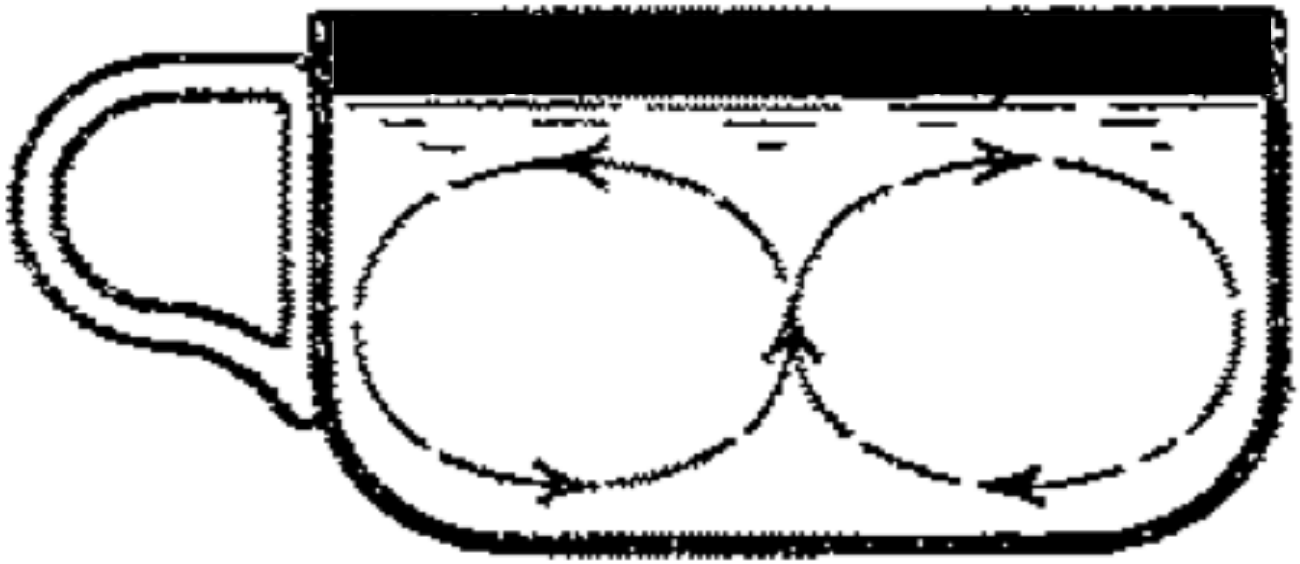


In our winter “Innsbruck” vortex the outward surface friction induced an upper secondary **cyclonic** circulation supportive to the upper cyclonic

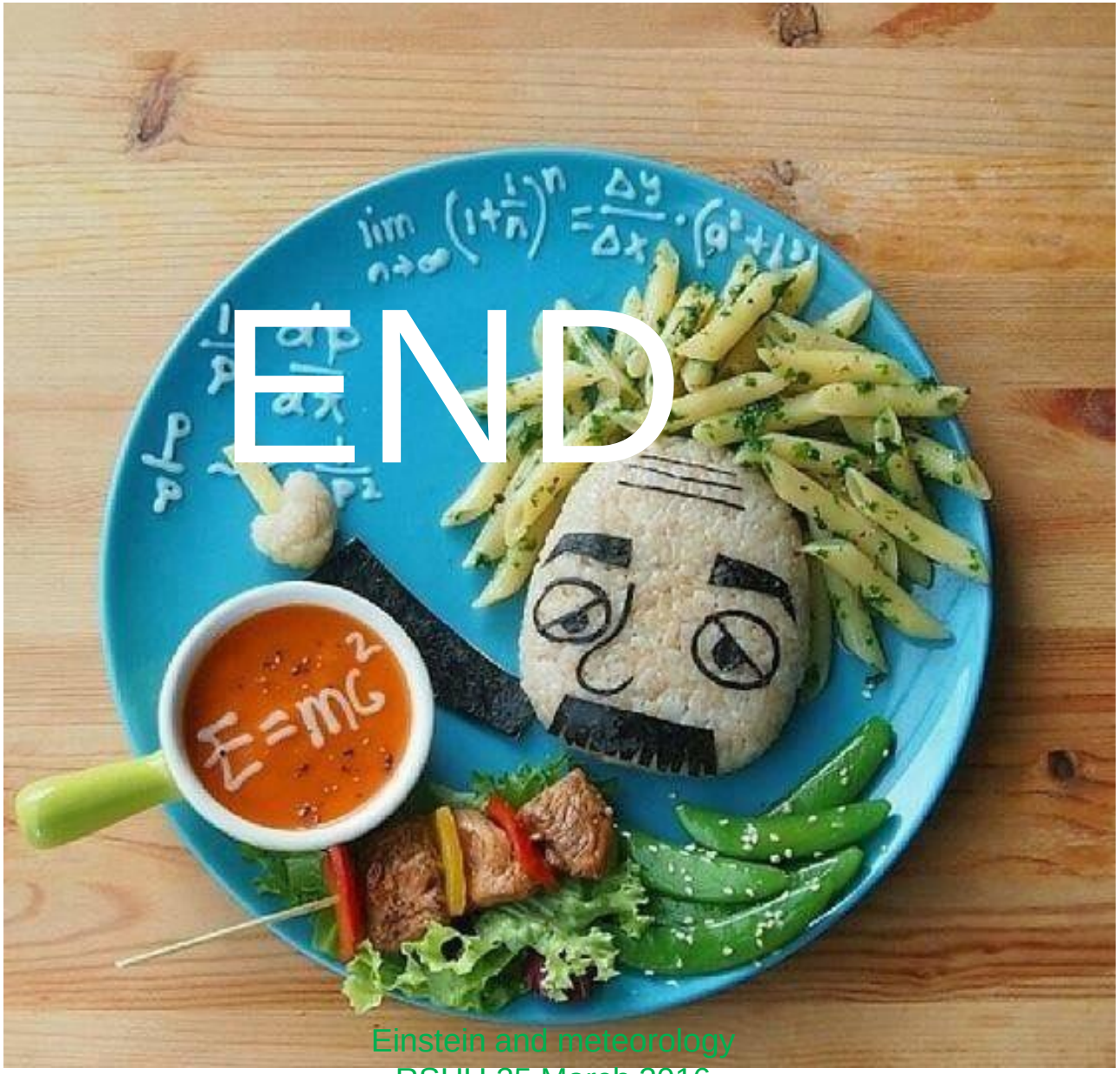


Was Einstein's explanation totally wrong?

No, it applies for a tea cup firm a firm upper lid



But that is another, non-meteorological story . . . .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